



**External Laser Small Form Factor Pluggable
(ELSFP) Implementation Agreement**

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ABSTRACT: This implementation agreement defines a form factor optimized for external lasers delivering continuous wave (CW) light to optical transceivers co-packaged within a system. They are field replaceable via a pluggable electro-optic blindmate connection. Details on the technical specifications and an appendix for application specific references such as parallel fiber eye safety references are included.

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Document Revision History

This is the first published revision to [OIF-ELSFP-01.0](#). It includes MAJOR mechanical revisions agreed to and voted on by the working group including changes to Figures 9,15,16,17,18,22,29,31, and 32 and the editor’s corrections of typographical errors.

1 Introduction

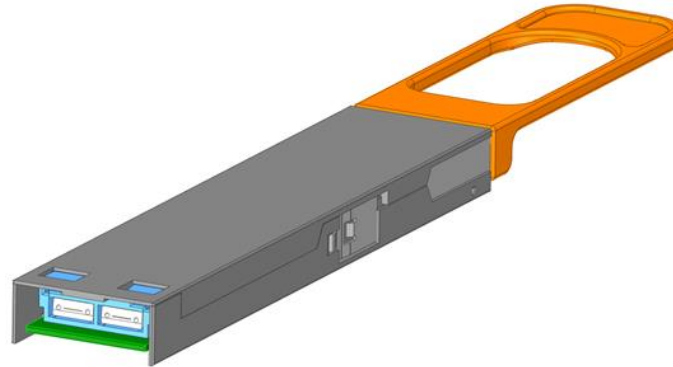


Figure 1 ELSFP module

The External Laser Small Form-Factor Pluggable (ELSFP) is a faceplate pluggable form factor to address the laser packaging requirements for co-packaged optical (CPO) systems with optical engines (OEs) which do not have integrated lasers, but rather choose to locate lasers external to the OE.

1.0 Objectives

The ELSFP module includes a blindmate optical connector to ensure a safe method to field replace lasers in the event of failure. Flexibility has been added to the form factor to enable a range of applications from massive scale data center switches to special purpose optically enabled ASICs.

1.1 Applications

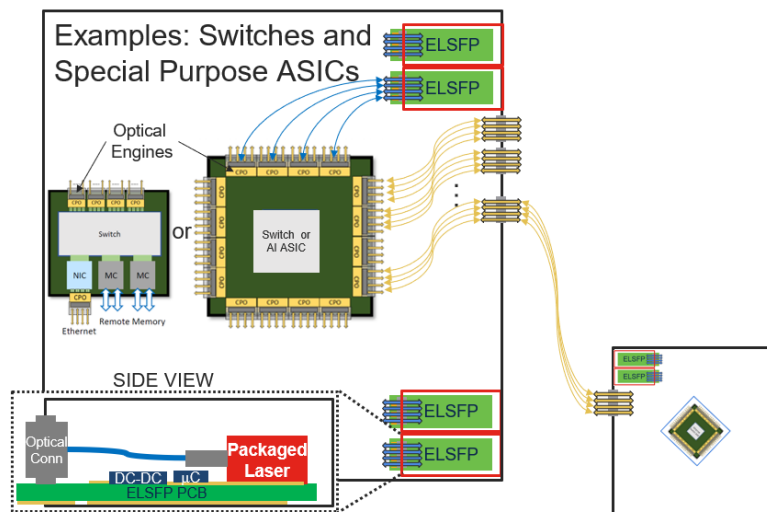


Figure 2 ELSFP in a co-packaged optics application

The ELSFP is targeted primarily at CPO applications, which may include but are not limited to the use of external lasers to provide optical power to the OEs incorporated in switches, network interface cards, artificial intelligent and machine learning application specific integrated circuits (ASICs), and more. The major advantages of this form factor are to reliably provide a replaceable light source package, couple that light in a safe way to maintain the system as an IEC 60825-2 Hazard Level 1 product, and decouple the thermal environment of the laser from that of the co-packaged ASIC assembly. Lasers have historically demonstrated significantly lower maximum reliable junction temperatures than silicon die (including silicon photonic circuit elements and germanium photodetectors). By placing the ELSFP at the faceplate of CPO systems (removed from the heat of the co-package ASIC and OEs) a more efficient cooling solution can be designed for these systems, and greater reliability is achievable with the fail-safe of a field replaceable pluggable module in case of a laser failure.

External Laser Source: Use Cases and Proposed Terminology

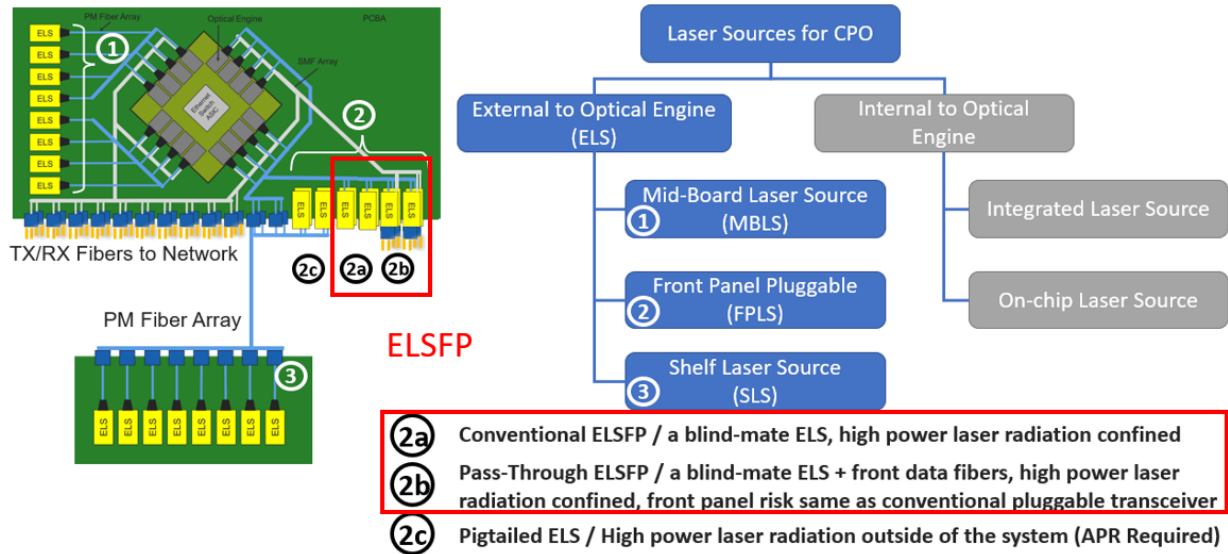


Figure 3 Possible laser solutions for Co-Packaged Optical Systems.

Figure 3 shows an example of the many possible solutions to provide laser light to CPO modules. The ELSFP defines 2 types of Front Panel Pluggable Laser Sources (FPLS) which enables a compact, eye safe, and versatile solution. Explicitly, 2a (Conventional ELSFP) and 2b (Pass-Through ELSFP) which are mechanically compatible with the same fundamental ELSFP port design assuming their keying features are compatible. These two options and the details of the hardware keys are discussed in greater detail in section 2. This modular approach also allows for reuse and feature upgrades as additional ELSFP modules become available.

2 Mechanical Specifications

2.0 Overall Description

The ELSFP solution consists of several discrete components:

1. An external laser pluggable module
2. A host connector that includes both an electrical interface to the module and an optical interface to the module, detachable from one another
3. A cage that provides module to connector alignment as well as EMI shielding and an interface to enable a riding heat sink to contact the ELSFP module

The below Figure 4, Figure 5, and Figure 6 illustrate the components. The ports are sized to enable multiple ELSFP units on various sized final system assemblies using either a single row of ports or two rows of ports based on connectors and cages that form a row on each side of a host PCB, commonly referred to as “belly to belly”.

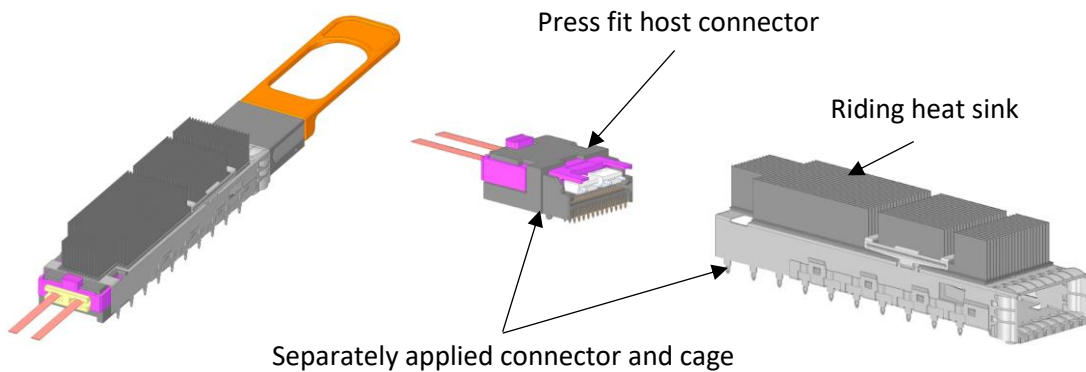


Figure 4 Host connector and cage

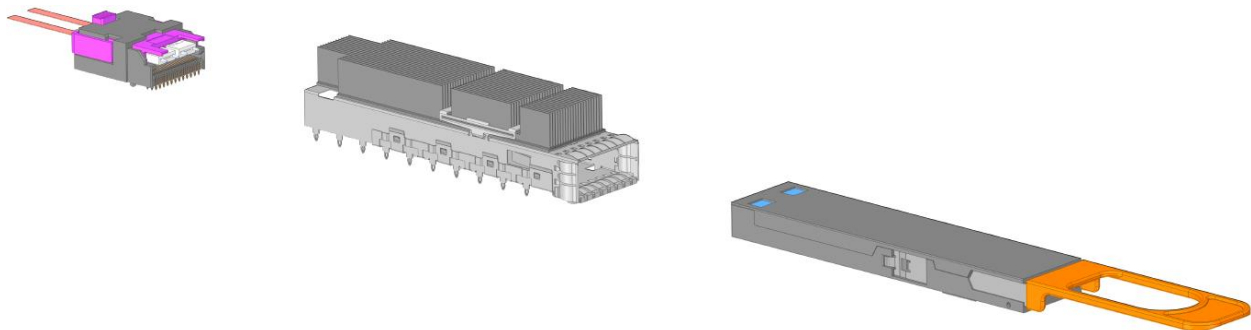


Figure 5 Host electro-optical connector, cage with heatsink, and ELSFP module

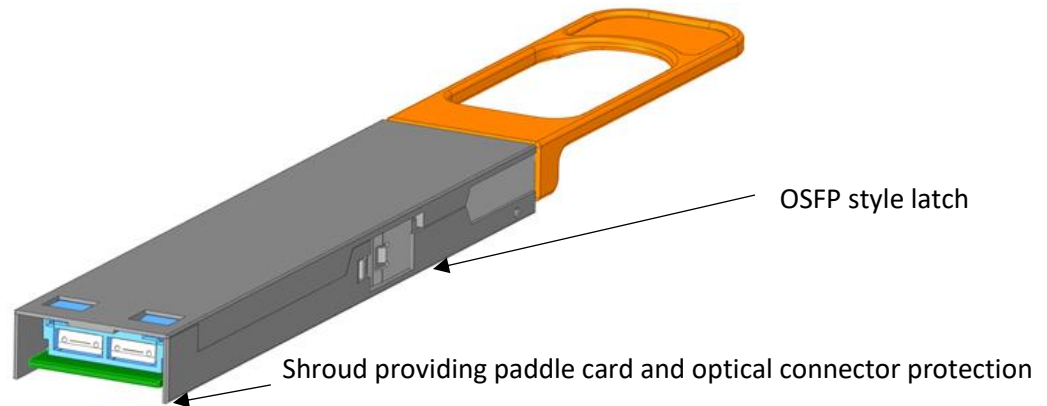


Figure 6 ELSFP module shroud and latch locations

Figure 7 provides some of the key module dimensions of the ELSFP. Along the length of the ELSFP dimensions reference the latch which is modelled after a conventional latch and pull-tab design similar to an OSFP module. The pull tab is allowed to extend from the front of the module and is used to release the latch from the cage of the module without the user needing to touch the front of the module, which is allowed to extend from the face plate of the system (which is roughly co-incident with the end of the cage) as seen in Figure 4. There are limited restrictions on the shape of the front of the module and as described in greater detail in section 6, the ELSFP may even have a front facing optical connector in the case of a Pass-Through ELSFP implementation. A few critical limitations are placed on the part of the module extending from the system.

- No extrusions shall be made at the base of the module which may result in a mechanical contention when two compliant modules are placed in a “belly-to-belly” configuration as diagrammed in Figure 27 and described in Section 2.0.
- The pull tab and any other attached elements protruding from faceplate (i.e., thermal assist features, fiber optic connectors with attached fibers at their specified minimum bend radius) should not extend greater than 127 mm (5 inches) from said faceplate so as to remain compatible with the vast majority of cabinet designs. End customer specifications may vary. Mechanical analysis should be done to confirm that such features do not put deleterious mechanical force on the cage and electro-optic connector under reasonably assumed field deployments.

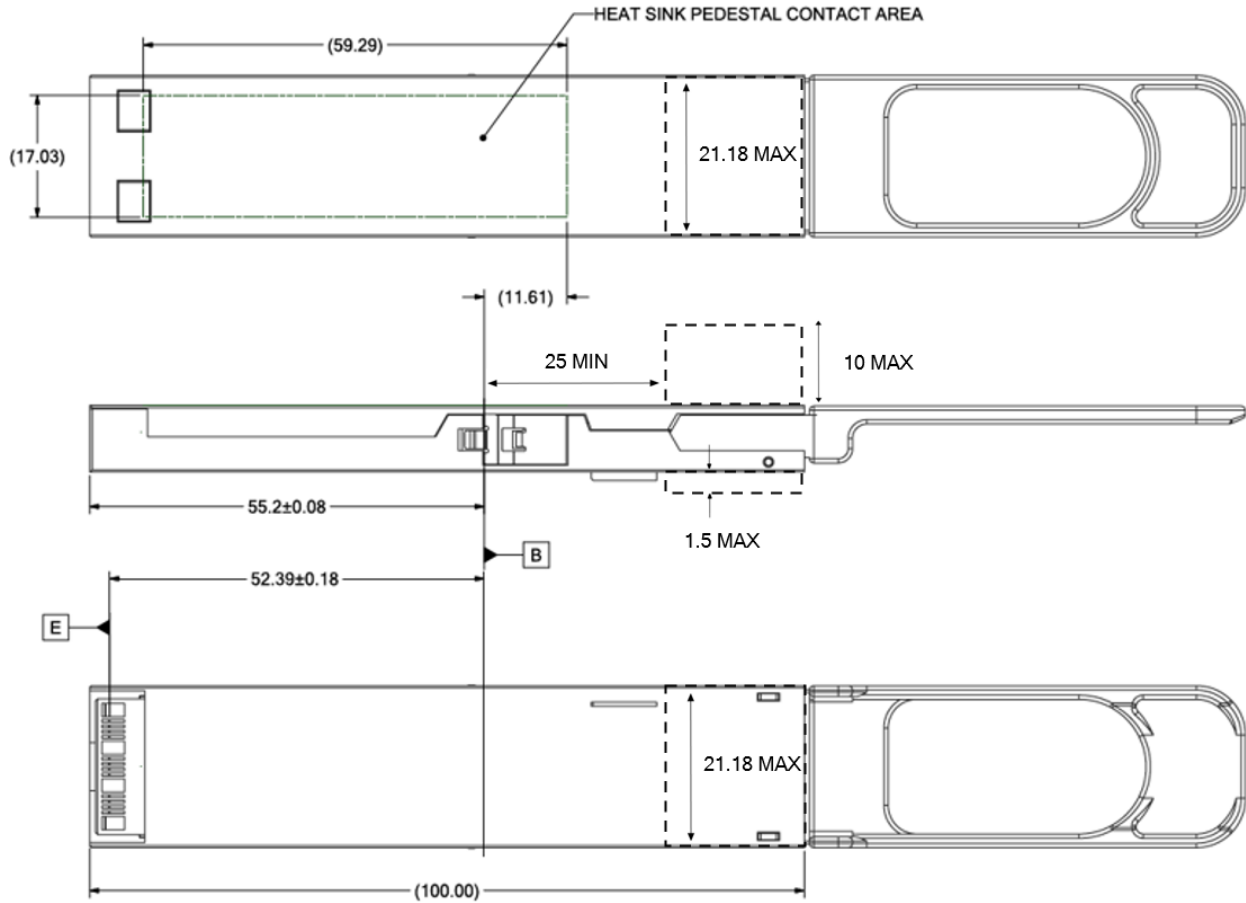


Figure 7 ELSFP latch location and length dimension

The thermal interface or heat sink pedestal for cage mounted heat sinks in the ELSFP assembly is called out in Figure 7. A mandatory label area is intentionally unspecified. Suggested contents of a module label are provided along with a reminder of some specified safety requirements in the references section. Additionally, the Figure 7 clearly shows the card edge connector and two ELSFP optical connector to shell mounting features which are a characteristic identifier for the ELSFP. The following sections provide greater details on the most critical interfaces of the ELSFP, starting with its blind-mate electro-optic connector. Finally, an optional extrusion is permitted on top or on bottom of the front of the ELSFP module. This can be used to enable front side optical connectors for Pass-Through ELSFPs or thermal management features such as heat sinks. Use of this optional feature shall be designed so as to minimally impact the inlet air flow around the ELSFP into the system.

2.1 Module Subsection

More detailed specifications for the ELSFP Module are provided in this subsection. Figure 8 defines the specification for rounded surfaces of the outer shell.

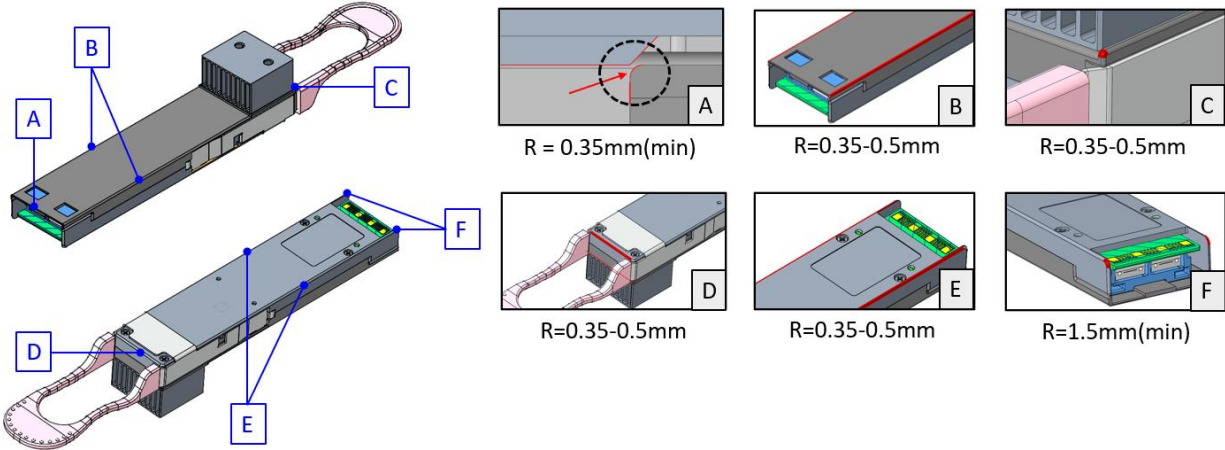


Figure 8 Rounding Specifications

The ELSFP module electro-optic connector end face is shown in Figure 9 including specifications for the board thickness, location, and dimensions for the module shell to properly mate with an ELSFP port.

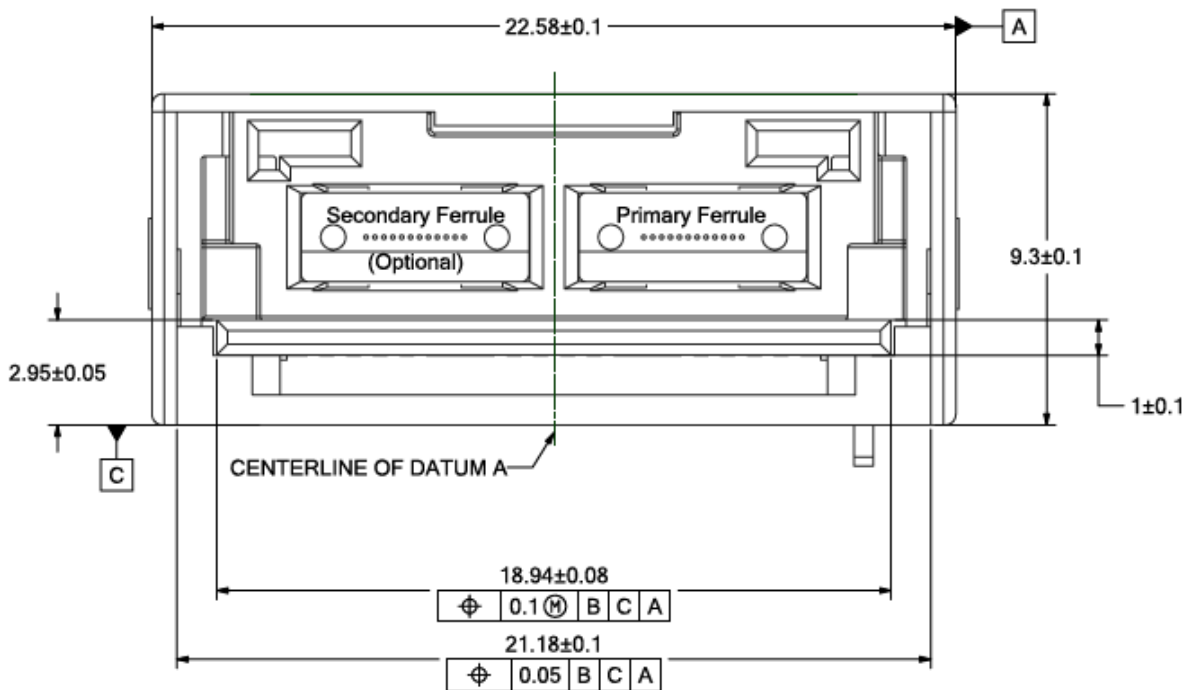


Figure 9 Module PCB interface tolerances

The card edge consists of electrical contacts only on the bottom side of the module. Figure 10 details the dimensional and tolerance requirements of each of the contacts of this electrical interface. A pinout diagram can be found in Figure 41.

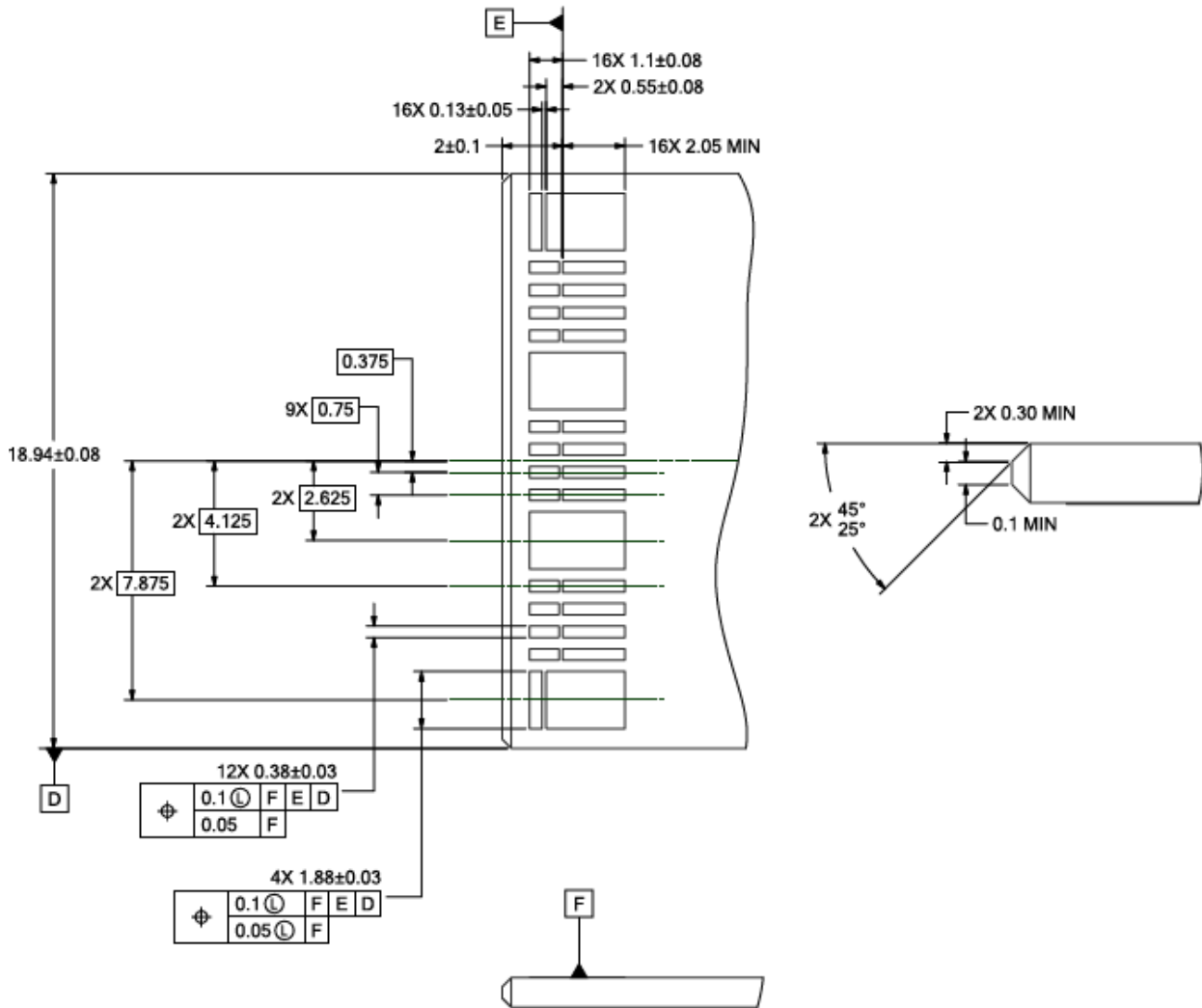


Figure 10 Module electrical pin and card edge tolerances

2.2 Blindmate Electro-Optical Connector and Cage Mechanical Specification

The ELSFP host connector is shown in Figure 11. The host connector is applied to the host PCB with a combination of electrical press fit pins and supplemental mechanical methods.

The host connector is configured to optionally accept an optical connector assembly which can house either one or two MT style ferrules insertable and removable from the rear of the host connector assembly.

2.2.1 Electrical Connector Interface Subsection

Figure 11 defines the location of the electro-optic interfaces relative to the system PCB. Detailed tolerances are provided for the opening in the electrical host connector to insert the optical host connector housing. Features have been included to allow this connector to latch into the electrical connector to form the complete electro-opto-mechanical assembly. Pillars at the base of the connector provide additional mechanical stability and are offset to enable either a single sided or belly to belly configuration. Additional definitions are provided for the bottom side host electrical pins.

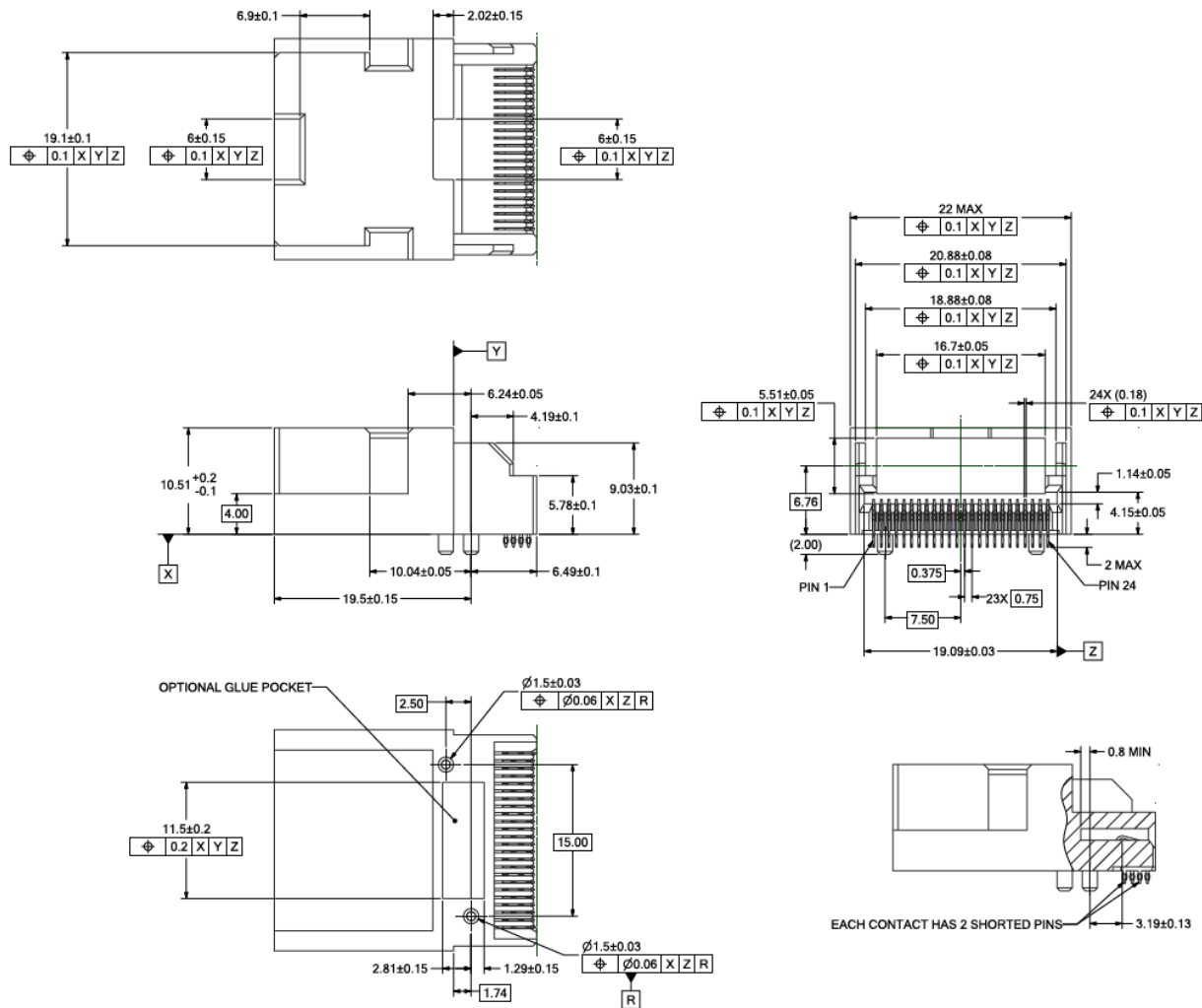


Figure 11 Host connector details

2.2.2 Cage Drawing

Figure 12 defines a single ELSFP cage specification. Additionally, faceplate bezels are defined for both single and 1x4 ganged cage configurations in Figure 13.

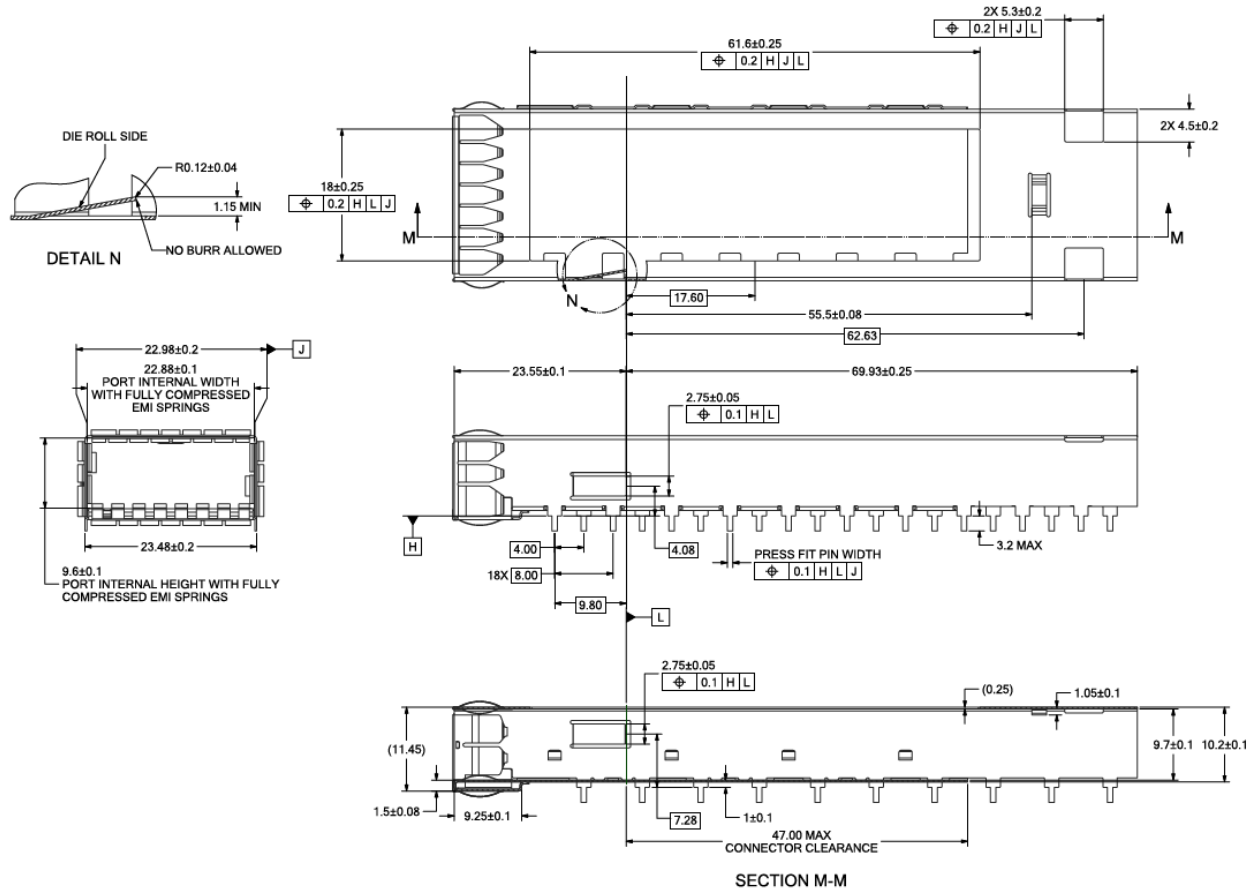


Figure 12 Cage details

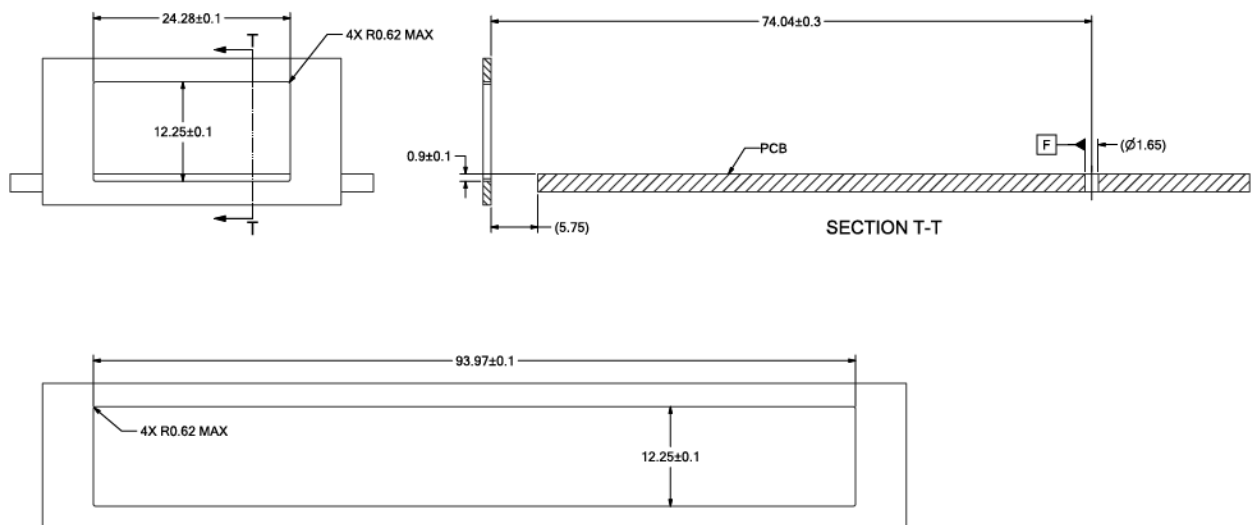


Figure 13 Faceplate bezels for 1x1 single and 1x4 ganged cages

2.3 Module thermal interface, flatness, and roughness

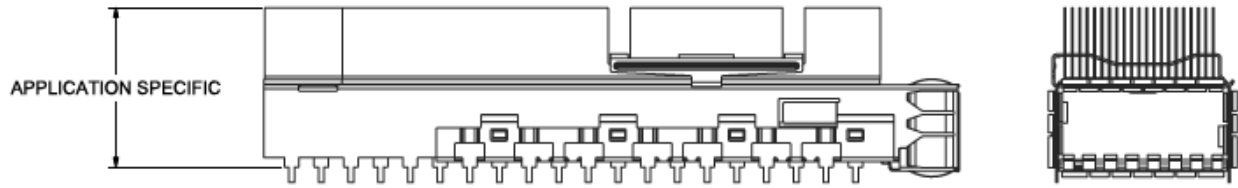


Figure 14 Example of a riding heatsink

The thermal management of the ELSFP module is provided by mounting a riding heat sinks on the cage ports. There is a single riding heat sink as shown in Figure 14. The host connector is configured such that the airflow from the riding heat sink is not blocked in a front to rear or rear to front direction to allow cooling. Alternate heatsinks with lateral airflow, or designed for liquid cooled or immersion systems are also options for the ELSFP.

ELSFP module flatness and roughness are specified to improve module thermal characteristics when used with a riding heat sink. Relaxed specifications are used for lower power modules to reduce cost. The module flatness and roughness specifications apply to the specified heat sink contact area for ELSFP by Figure 7. Specifications for ELSFP Module flatness and surface roughness are shown in Table 1. Flatness and roughness specifications apply to both top and bottom surfaces of the modules.

Table 1 ELSFP module flatness and roughness specifications

Thermal Performance Target	Module Flatness (mm)	Surface Roughness (Ra ^[21] , μm)
Basic	0.075	1.6
Typical	0.05	0.8
Enhanced	0.025	0.4

2.4 Host connector and cage footprints

Footprints for the electrical host interface and mechanical attachment points for the cages are shown in this section. Configurations shown for systems which only have ELSFPs on a single side of the system PCB are referred to as “single sided”. For the cases in which both sides of the system PCB have an ELSFP located at the same lateral location, the bottom shell of the ELSFP (or belly) is facing the system PCB for modules on both sides of the board. This configuration is referred to as “belly to belly”. They are divided into the following configurations with PCB footprints in the figures referenced:

Single module cages:

- Figure 15 Single sided (1x1) host connector and cage footprint
- Figure 16 Belly to belly (1x1) host connector and cage footprint

Ganged module cages for higher density:

- Figure 17 Single sided (1x4) Ganged host connector and cage footprint
- Figure 18 Belly to belly (1x4) Ganged host connector and cage footprint

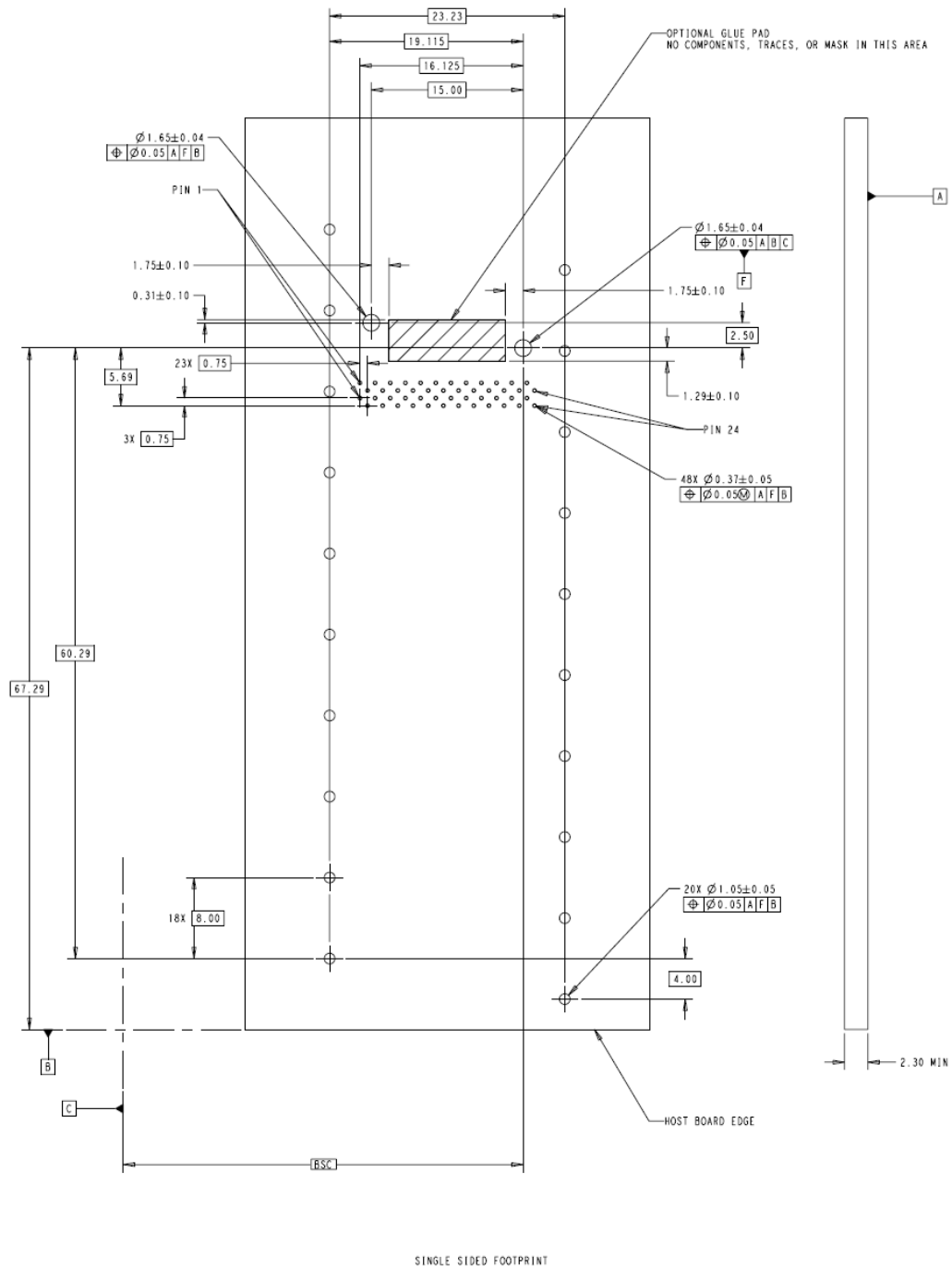


Figure 15 Single sided (1x1) host connector and cage footprint

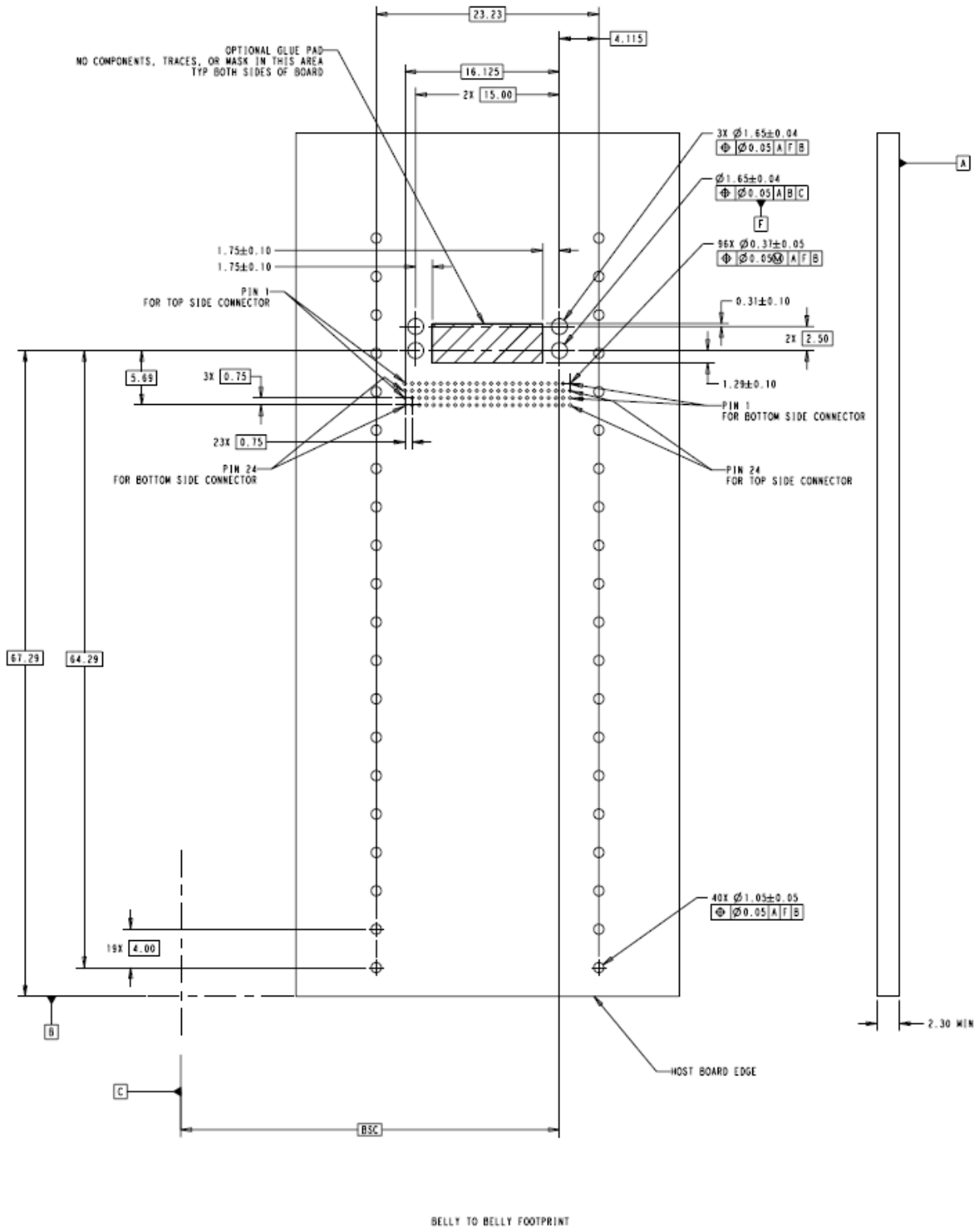


Figure 16 Belly to belly (1x1) host connector and cage footprint

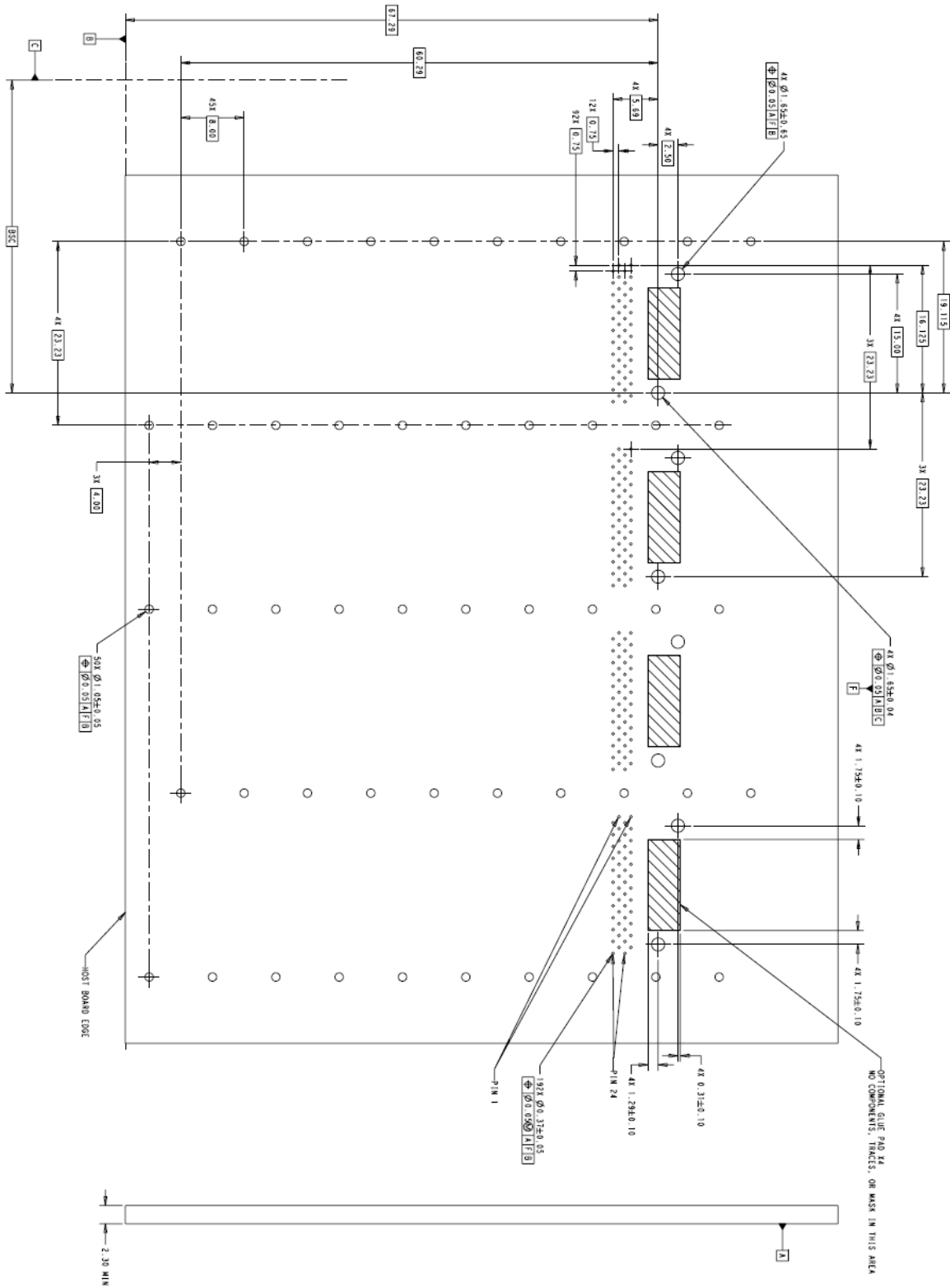


Figure 17 Single sided (1x4) Ganged host connector and cage footprint

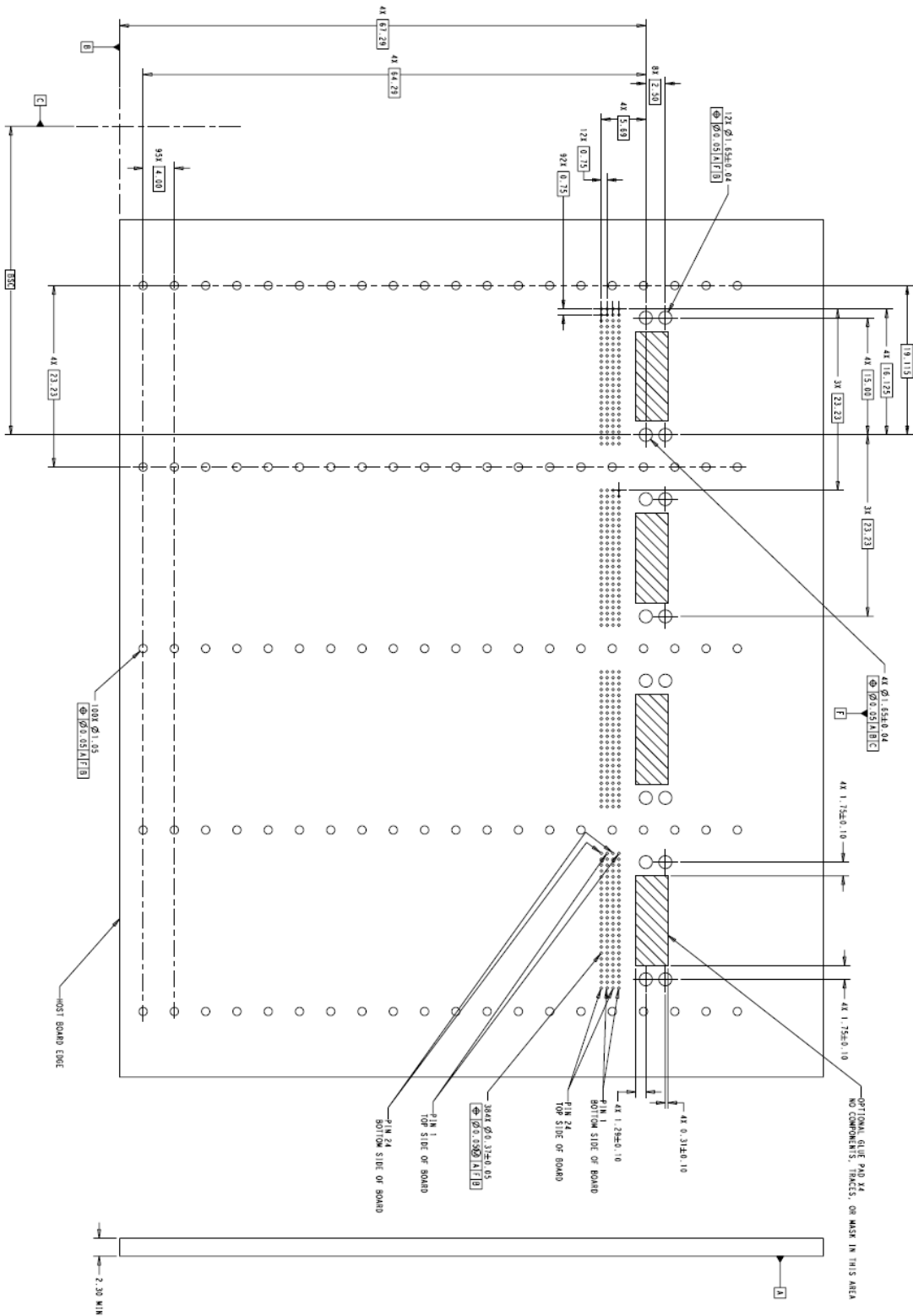


Figure 18 Belly to belly (1x4) Ganged host connector and cage footprint

2.5 Module Keying

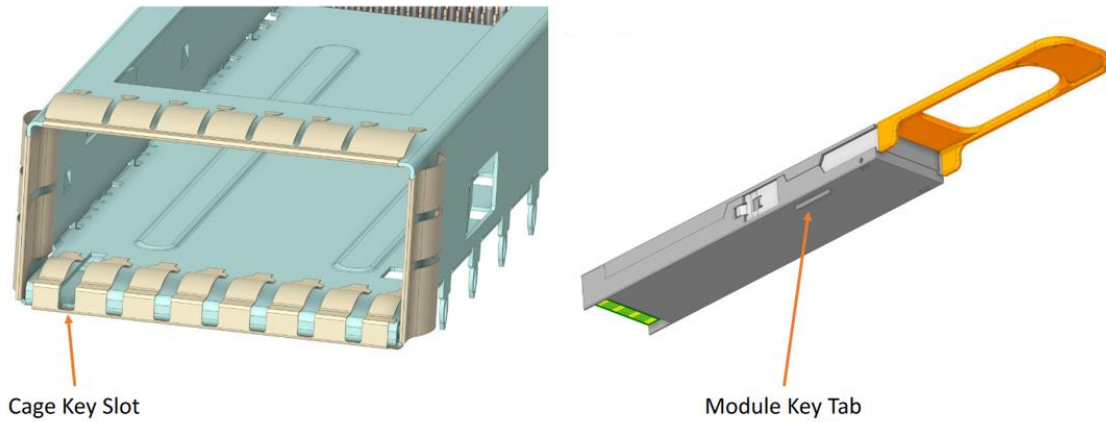


Figure 19 ELSFP single tab module keying scheme

ELSFP modules shall have key tabs in the bottom of their shell which mate with cage key slots between the EMI gaskets at the face plate as shown in Figure 19. This hardware keying scheme is specified to ensure that the appropriate fiber connections are made when engaging an ELSFP module (Figure 21). It also protects both host side and module side electro-optical interfaces from upside down inserts. If no tabs are placed on the ELSFP module there would be a of risk damaging the optical connector as shown in Figure 20. Therefore at least 1 key tab is required. Key slot dimensions are specified in Figure 22.

Module key stops against cage when inserted upside down

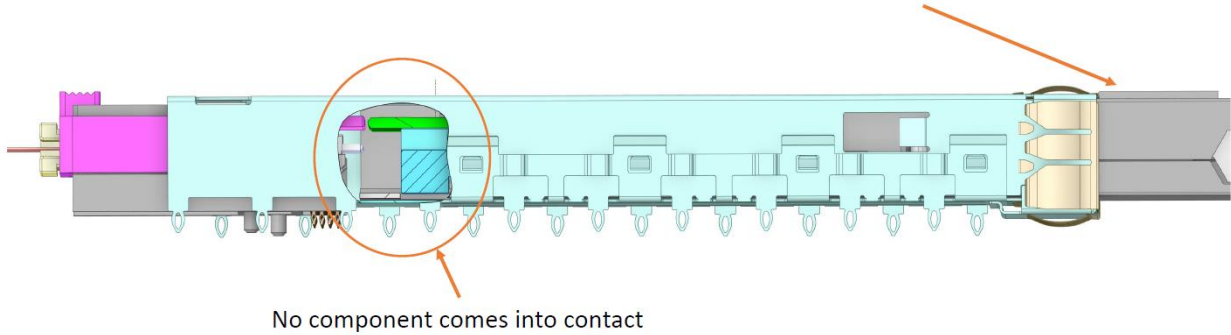


Figure 20 Keying prevents upside down module insert

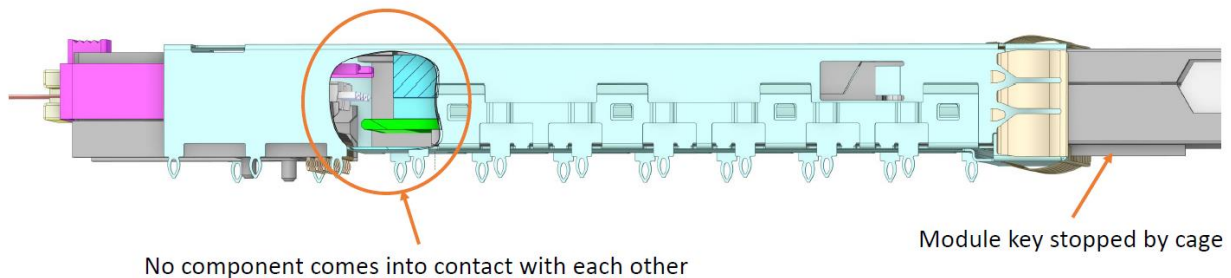


Figure 21 Keying prevents mating modules to incompatibly keyed ports

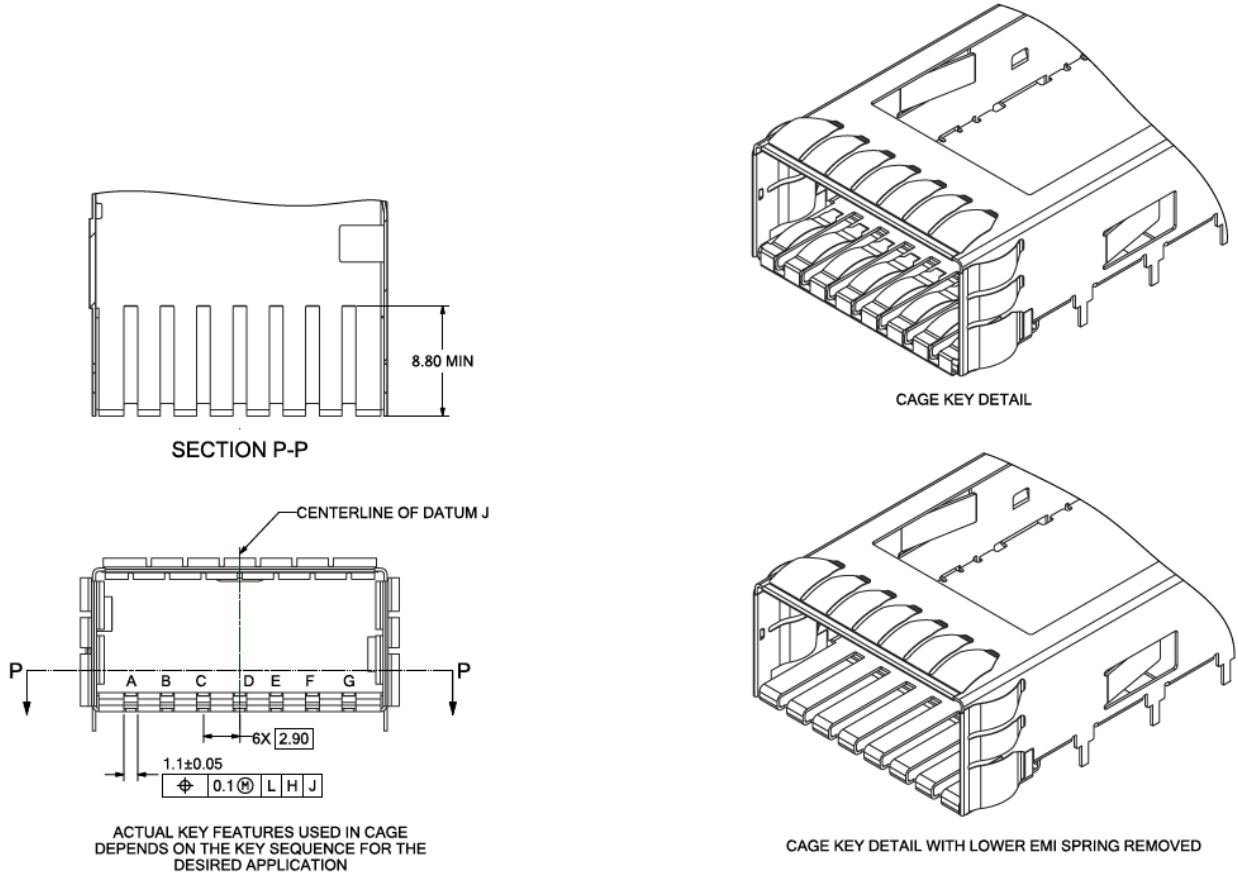


Figure 22 Hardware keying slot and tab dimensions

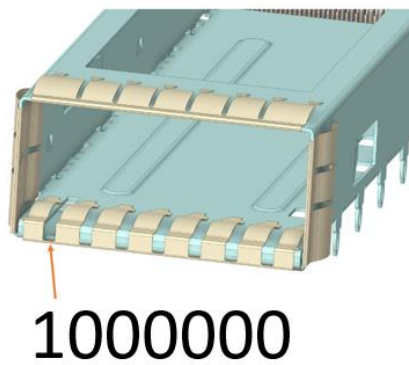


Figure 23 Keying nomenclature

The keying nomenclature from Figure 23 uses 7 bits representing each of the potential key slots of the cage from left to right when looking into the host port, where “1” has key tab/slot, “0” has no key tab/slot. Figure 25 provides a pictorial table of the possible keys corresponding to 1 or 2 optical ferrules and different row counts of fibers. Modules with two ferrules of the appropriate row count may mate into ports with only one host ferrule populated. However, the host is responsible during bring up to identify if such a two-ferrule module is able to support the needs of the system and will only activate

fiber channels from the mated ferrule. This offers the host the ability to provide some backwards compatibility if an early generation module only uses 1 ferrule, and later generations adopt a second.

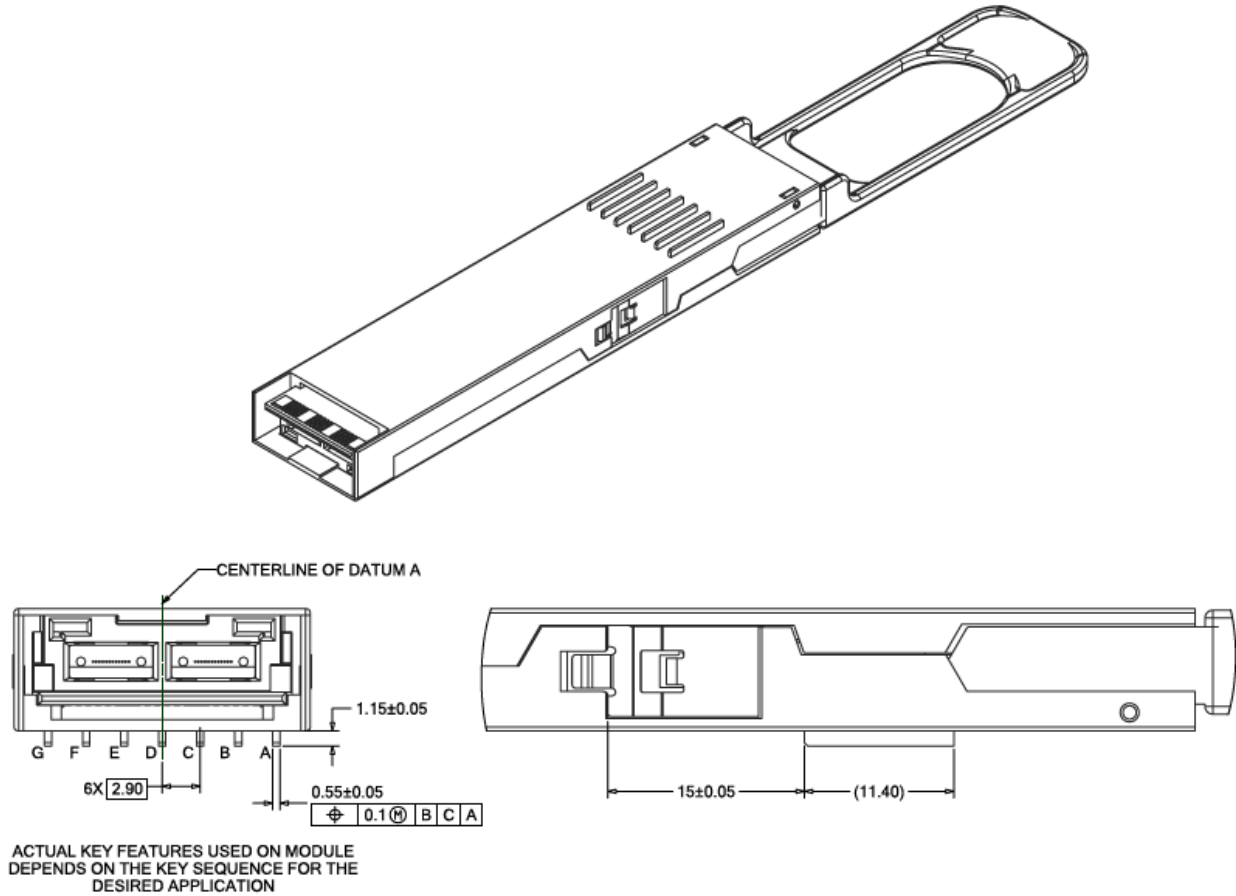
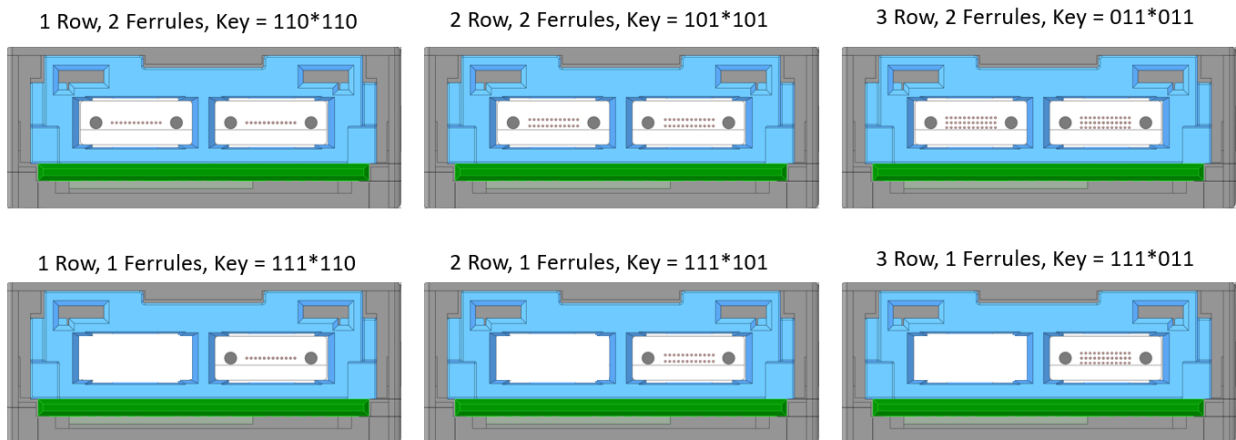


Figure 24 Key tab dimensions



* Indicates the presence or absence of pass-through fibers in the pluggable.

Figure 25 Hardware keying to match fiber scheme

Reference is also made for the 4th bit in the keying scheme to represent the presence (0) or absence (1) of fibers which pass through the pluggable from the host optical connector to a front side faceplate connector as diagramed in Figure 26. The *****1***** key is selected to signify a “Conventional ELSFP” without any non-laser fibers in the host connector. In this case all fibers are dedicated to the delivery of laser power from the ELSFP to the system via the blind-mate optical connector at the rear to the ELSFP.

An alternate module type, the Pass-through ELSFP is also allowed. This is an option for the ELSFP which allows significantly more dense systems by freeing up face plate real estate and leverage the front side of the ELSFP to meet end customers’ optical connector requirements. The existence of “pass-through” fibers on the host connector is keyed by *****0*****. This allows an operator in the field to mate a “Pass-Through ELSFP” of the appropriate number of rows of fibers (i.e., 1 row with 4 PMF laser fibers and 8 SMF pass through fibers) to a port keyed for a conventional ELSFP (i.e. 1 row with only 4 PMF). The module’s front side optical connectors and pass-through fibers would not be used, but the module could still support the requirements of the system. The converse mating is disallowed because a Conventional ELSFP would not support a system requiring a Pass Through ELSFP. A pass-through module may support a system with a conventional port if the laser fiber count and power class requirements are met, but the opposite is not true and could result in stray light entering the ELSFP module from the system and missing optical interfaces on the front panel. As can be seen in Figure 23 a user can identify the keying requirements of a port by examining the slots between the EMI springs and tabs on the ELSFP module.

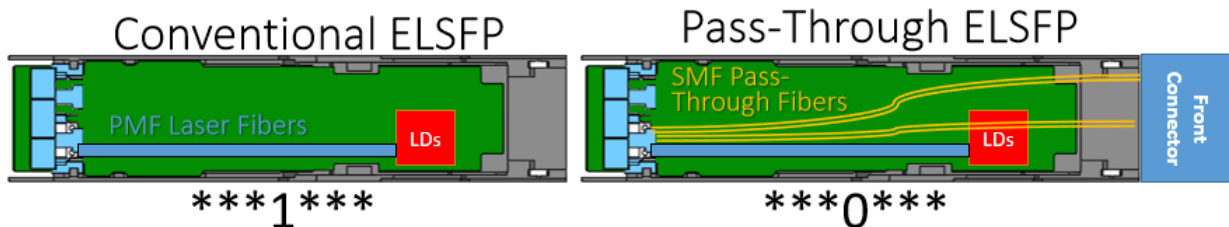
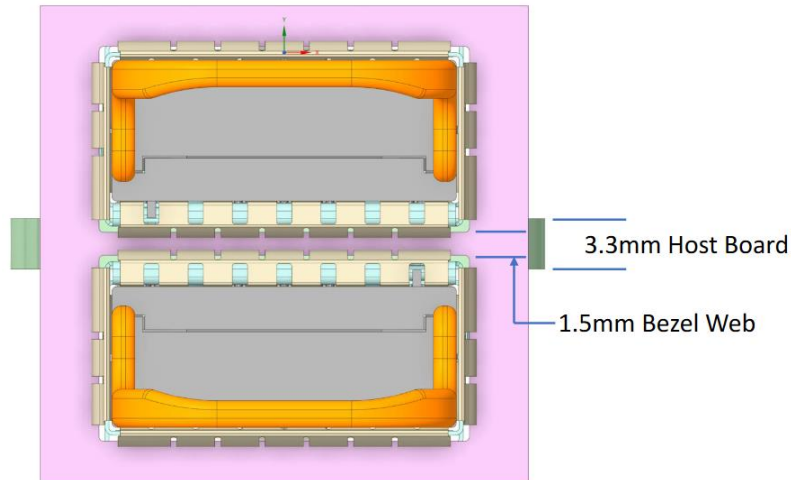
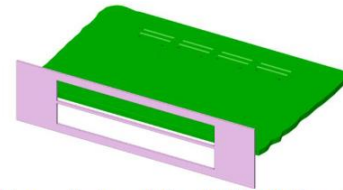


Figure 26 Keying for Conventional versus Pass-Through ELSFP

Modules and ports with a mismatch in the number of laser fibers and optical power class are allowed to mate. However, it is the responsibility of the host system to identify the level of support such a module can provide and report to the user this information. Similarly, other mismatches in laser properties and port expectations, such as the wavelength, laser fiber count, electrical power class, etc. are the responsibility of the host to identify during bring up and inform the user or use partial functionality of the ELSFP module (i.e. only power 4 of the port required laser fibers out of the 8 available in a module), details on this level of management is defined in the Implementation Agreement for ELSFP CMIS.



In belly to belly applications, the minimum board thickness will be dictated by the minimum bezel web width that will work in the specific application. For example, if the minimum web width is 1.5mm, the minimum board thickness will be 3.3mm



Example bezel for 1x4 ELSFP cage in a belly to belly configuration

Figure 27 Board thickness versus bezel web width

Figure 27 highlights specific requirements for belly-to-belly systems. Using the bottom shell key tab system puts specific requirements on the webbing of the bezel of the faceplate and the minimum board thickness. Particularly in the case of a 1x4 cage careful attention should be paid to these related geometries in order to design a manufacturable system which also is EMI compliant.

3 Module Optical Interface Specification

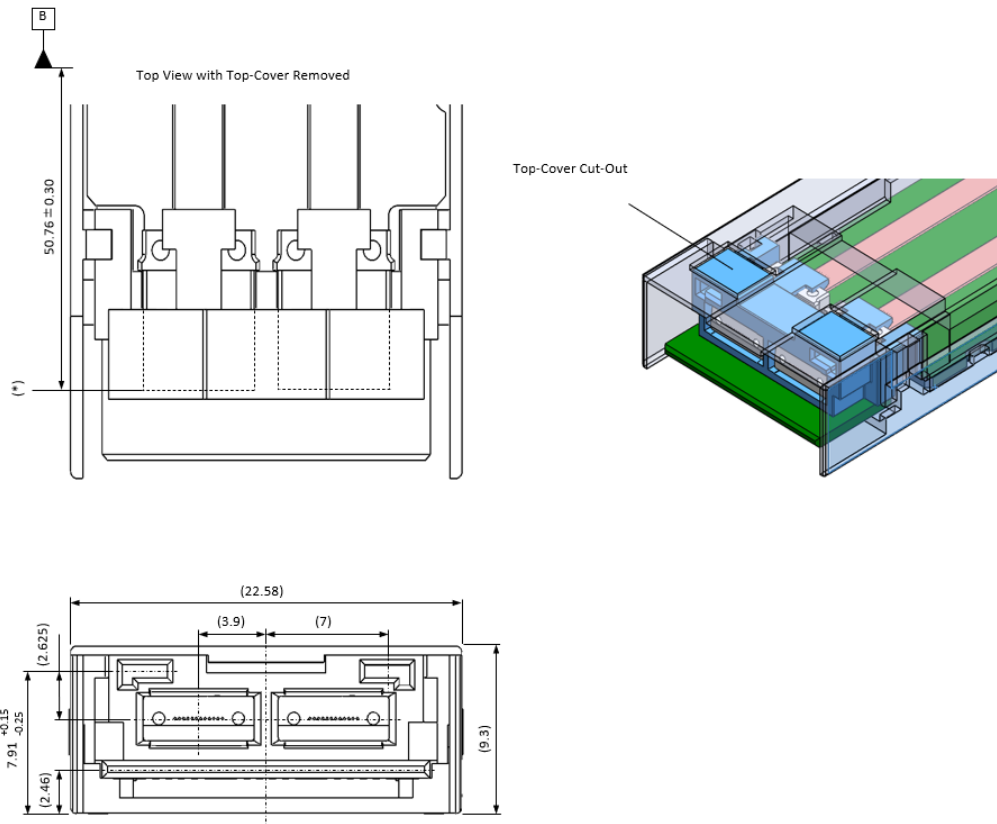
3.0 Blindmate Optical Connection

Optical connection to the ELSFP is made through a blindmate connector, whereby an optical connector assembly on the backside of the ELSFP module is mated with an optical connector assembly on the host connector. The optical connector assemblies possess coarse alignment features that engage prior to the engagement of the fine-alignment guide pins/holes on the multi-fiber ferrules, detailed further below. The optical connector assemblies shall accommodate either dual-ferrule or single-ferrule configurations populated with two or one ferrule, respectively. Optical connectors shall otherwise consist of the same optical housing components regardless of ferrule count. They shall be detachable from the electrical connector to separate the PCB assembly from the optical assembly. Figure 33 shows adjacent host side and module electro-optical interfaces with the correct single populated ferrule.

3.1 Dual-Ferrule Configuration

In the event of a dual ferrule configuration, the two ferrules shall be placed side-by-side above the module electrical card edge connector as dimensioned in Figure 28.

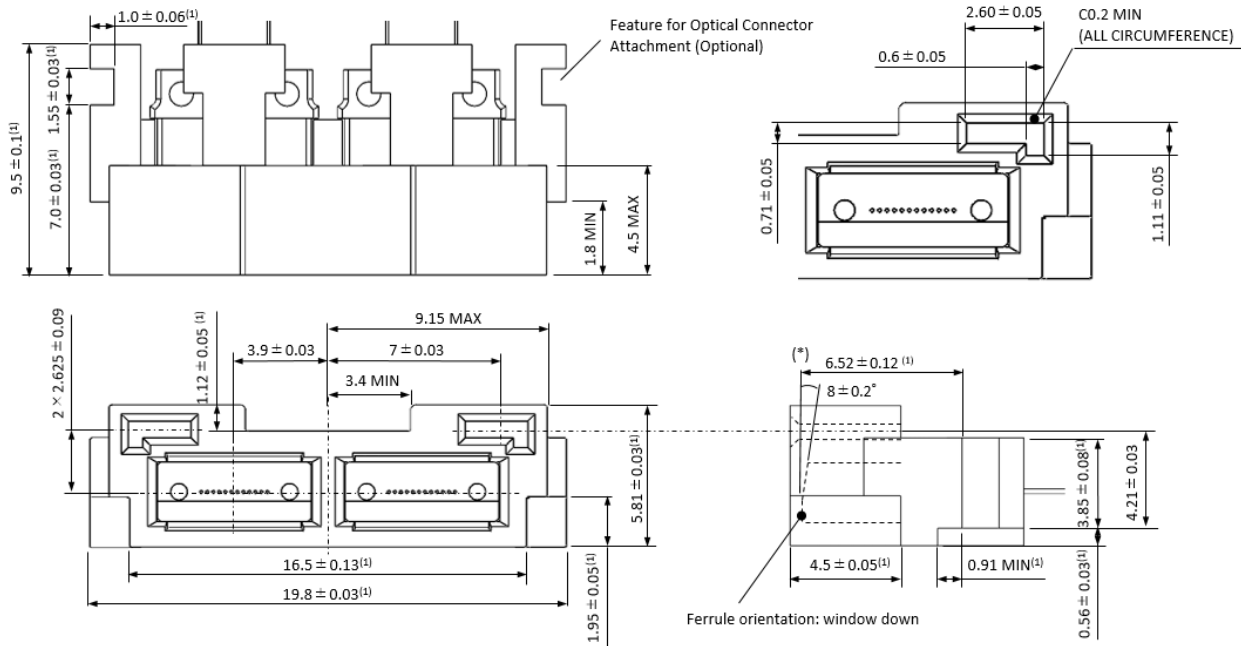
3.1.1 Module-Side Optical Connector



* Line indicates position of optical reference plane, when mated with the host connector. i.e. this is the furthest position the ferrule can be pushed back towards Datum B.

Figure 28 Module-side optical interface

Figure 29 shows the module-side optical connector. The connector consists of a connector housing, and up to two fiber ferrules. There are no springs in the module-side optical connector, the mating force with the host-side is provided by the individual springs for each ferrule on the host-side optical connector. The housing features two guide-holes for coarse alignment with the host-side optical connector. The height of the connector housing is higher on the two sides, to ensure sufficient wall thickness and hence mechanical strength around the coarse-alignment guide holes. The optical connector does not possess a latch to mate with the host-side connector, but instead relies on the module-to-cage latch.



⁽¹⁾ Informational dimensions

* Line indicates position of optical reference plane, when mated with the host connector. i.e. this is the furthest position the ferrule can be pushed back towards Datum B.

Figure 29 Module-side optical connector

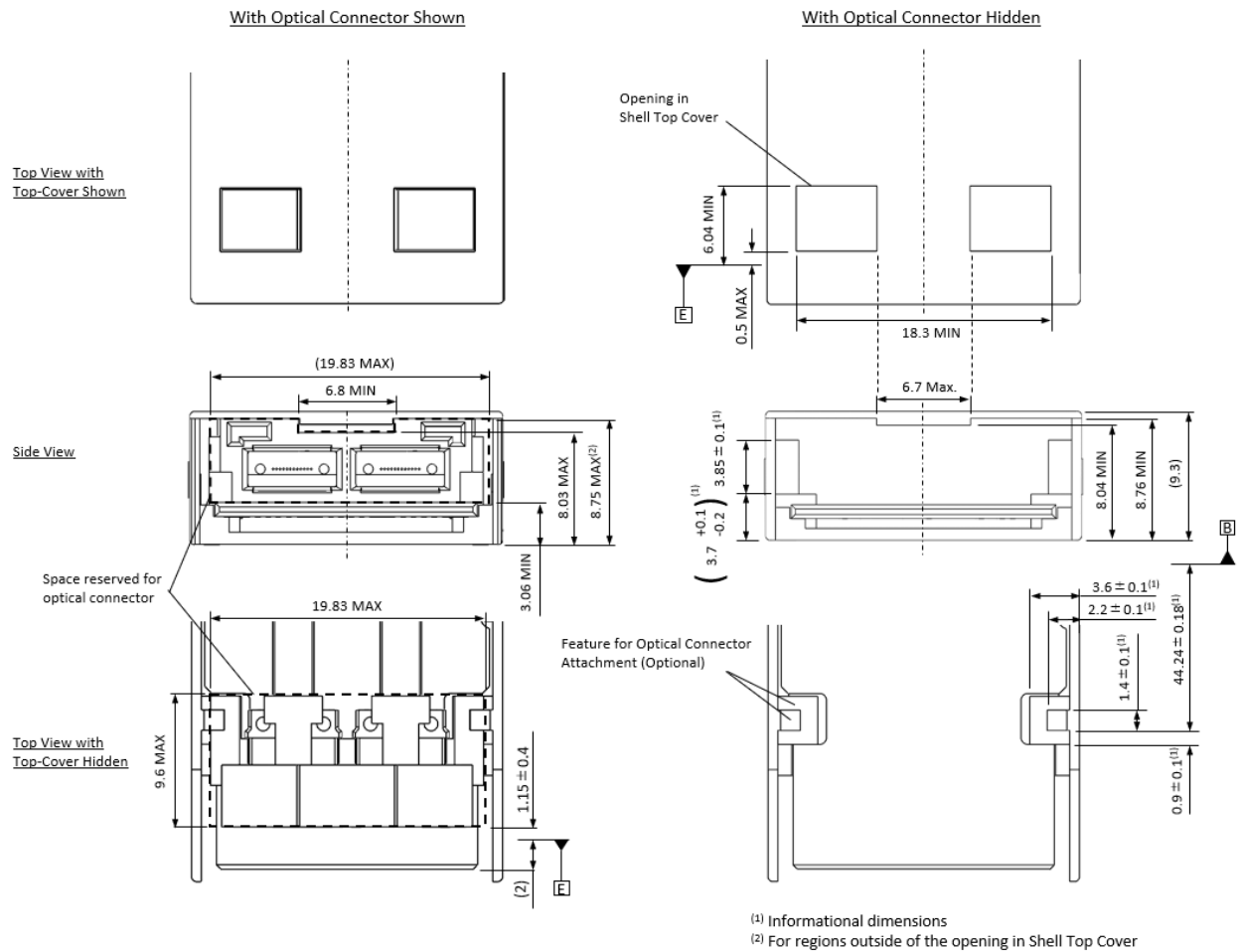


Figure 30 ELSFP module with optical connector

Figure 30 shows the optical connector integrated with the ELSFP module. The optical connector is enclosed and protected within the module shell. An optional connector-to-module attachment is also shown.

3.1.2 Host-Side Optical Connector

Figure 31 shows the host-side optical connector. The connector consists of a connector housing, and up to two MT style ferrule subassemblies. The connector housing possesses guide features for coarse-alignment with the module-side optical connector.

The host-side ferrules are “pinned” (possess guide-pins) for fine alignment, to engage with the “unpinned” guide-holes of the module-side ferrules. The ferrules are aligned when the coarse-alignment features on the connector housing engage with the module-side connector housing, after which the ferrule guide-pins/holes of the ferrules engage. The host-side ferrules individually are spring-loaded within the ferrule subassembly, such that during the mating process, the ferrules comply as the facets of the host-side and modules-side come into contact and pressure is applied to latch the module into the cage.

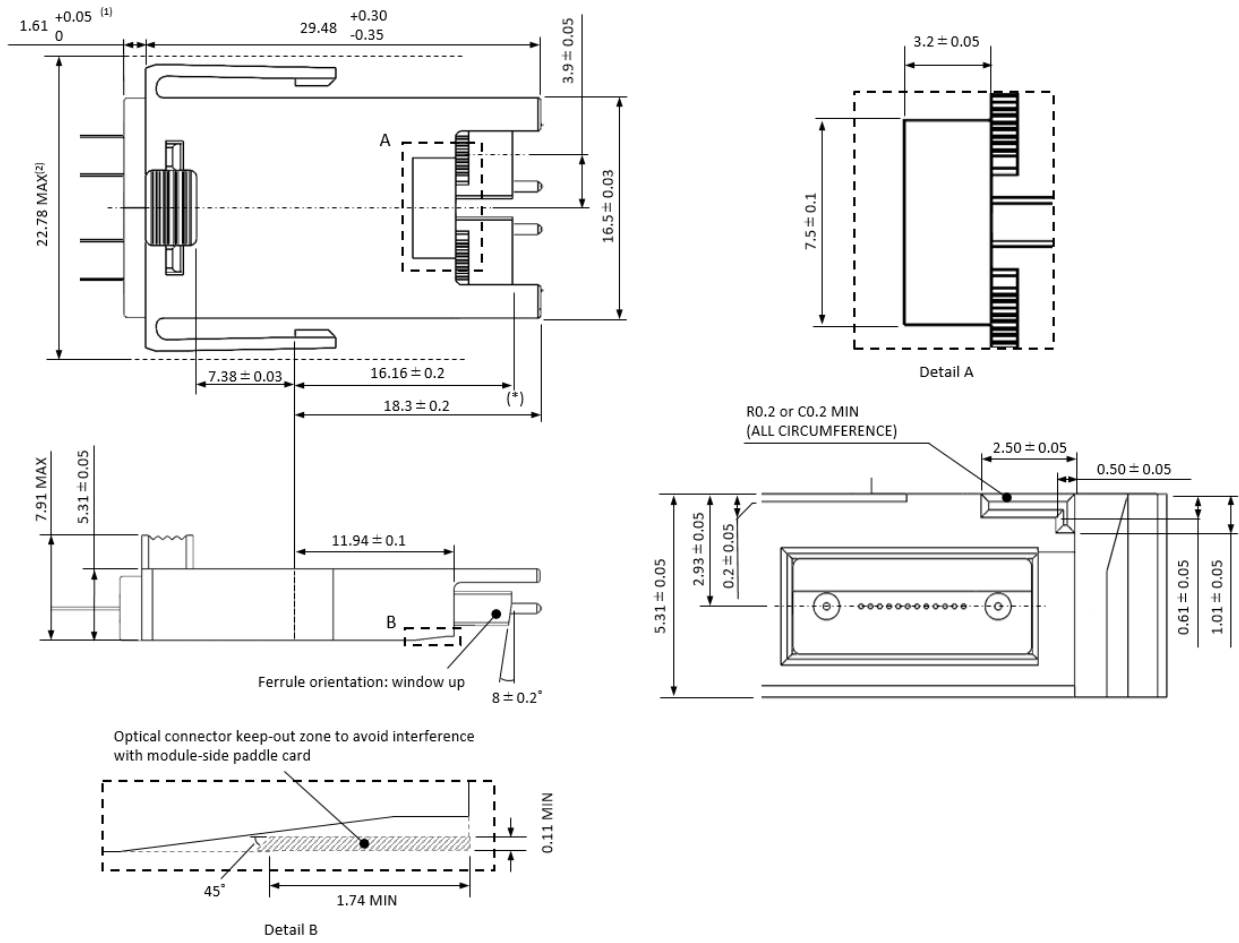
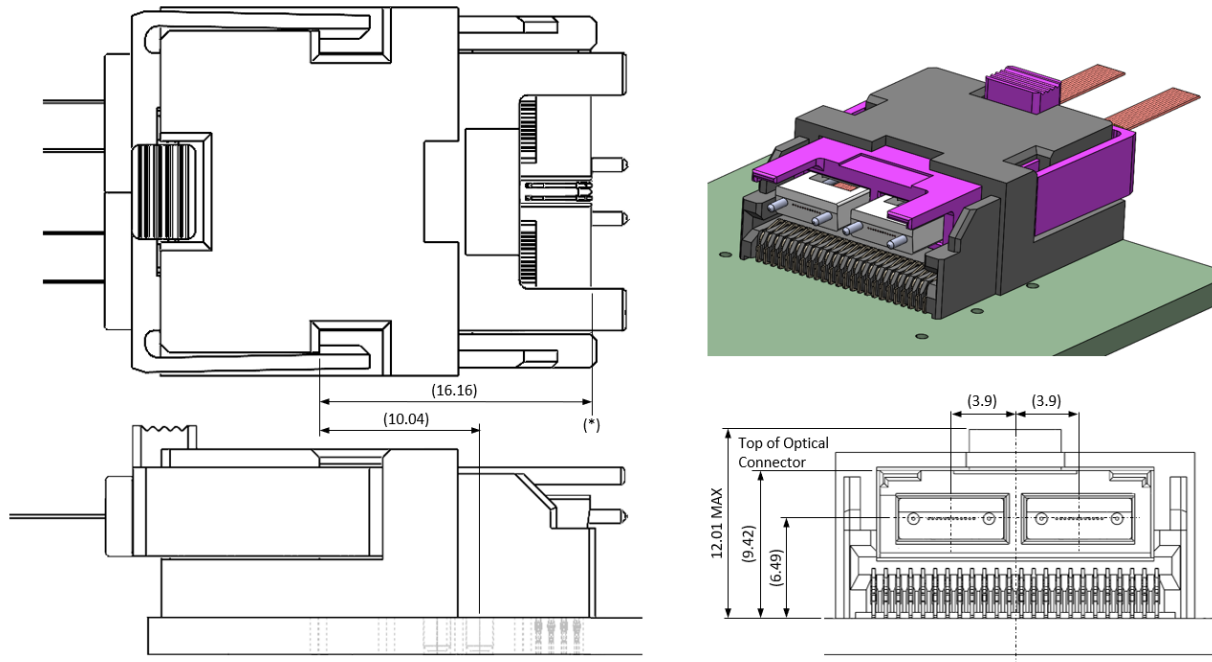


Figure 31 Host-side optical connector



* Line indicates position of optical reference plane, when the host connector is not mated with the module-side connector.

Figure 32 Host connector assembly

Figure 32 shows the optical connector integrated with the host connector. The optical connector is plugged in/out to the host from the system-side and is held in place via the latches on the sides of the optical connector.

3.2 Single-Ferrule Configuration

The single-ferrule configuration consists of the same optical connector components as the dual-ferrule configuration, except that the module-side optical connector assembly is populated with only one ferrule. In the single-ferrule configuration, the ferrule shall be populated on the left side of the ELSFP module and host connector as viewed while inserting the module into the system's front panel, as shown in Figure 33.

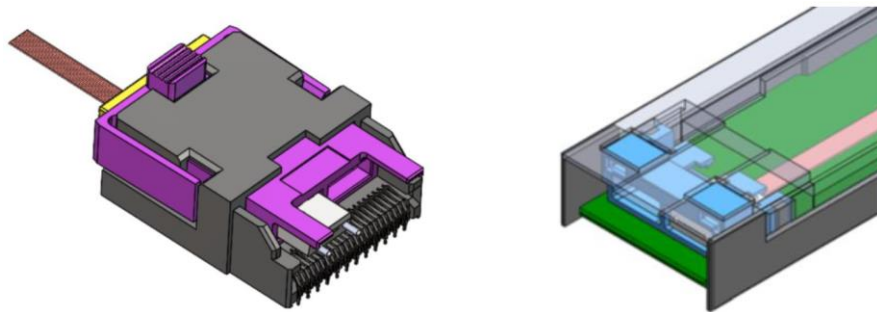


Figure 33 Single-ferrule configuration

3.3 Ferrule Requirements

The multi-fiber ferrules may be implemented with physical contact MT ferrules, or with MT-compatible air-gap type ferrules (referred to hereafter as “air-gap ferrules”).

Both physical contact and air-gap ferrules use a 12 fiber MT ferrule as defined by TIA-604-5, IEC 61754-7-1 and IEC 61755-3-31; a 24 fiber MT ferrule as defined by TIA-604-5 and IEC 61754-7-2; or a 36 fiber MT ferrule as defined by TIA-604-5. The ferrules shall be angle-polished at $8\pm 0.2^\circ$, as defined in IEC 61755-3-31. Ferrule alignment pins shall reside on the host side ferrules. Specific guidance on MT alignment pin diameter, alignment hole diameter, and pitch are given in Table 2.

Table 2 MT ferrule specifications

	12 Fiber MT	24 Fiber MT	36 Fiber MT
MT Alignment Pin Diameter	<u>TIA-604-5:</u> Table 3, Option t=1 <u>IEC 61754-7-1:</u> Table 4, Dimension A	<u>TIA-604-5:</u> Table 3, Option t=1 <u>IEC 61754-7-2:</u> Table 5, Dimension A	<u>TIA-604-5:</u> Table 3 Option t=1
MT Alignment Hole Diameter	<u>TIA-604-5:</u> Table 3, Option t=1 <u>IEC 61754-7-1:</u> Table 1, Dimension A	<u>TIA-604-5:</u> Table 3, Option t=1 <u>IEC 61754-7-2:</u> Table 2, Dimension A	<u>TIA-604-5:</u> Table 3 Option t=1
MT Alignment Pin/Hole Pitch	<u>TIA-604-5:</u> Tables 5 & 12, Dimension C <u>IEC 61754-7-1:</u> Table 1 & 4, Dimension C	<u>TIA-604-5:</u> Tables 5 & 12, Dimension C <u>IEC 61754-7-2:</u> Table 2 & 5, Dimension C	<u>TIA-604-5:</u> Tables 5 & 12 Dimension C
MT Fiber Pitch	<u>TIA-604-5:</u> Figure 3.2.3a <u>IEC 61754-7-1:</u> Figure 4	<u>TIA-604-5:</u> Figure 3.2.3b <u>IEC 61754-7-2:</u> Figure 4	<u>TIA-604-5:</u> Figure 3.2.3c

The ferrules on the module-side optical connector are angle-polished MT ferrules, without any anti-reflection (AR) coating. The host-side ferrules can be either uncoated MT ferrules, or air-gap ferrules which are MT-compatible ferrules but with spacers on the ferrule end-face. This allows the choice of a physical-contact or air-gap optical mating, determined by the choice of ferrules on the host-side, as shown in Table 3. While an AR-coated ferrule on the module side would provide the best air-gap mating performance, this requires additional hardware keying to distinguish the ferrule type on the module side, to prevent the unwanted mating between AR-coated module-side ferrule and uncoated physical contact ferrule on the host side. Therefore, only uncoated ferrules on the module-side are allowed in this IA.

The air-gap ferrules shall have additional requirements as follows. A spacer is applied to the perimeter of the host side ferrule as shown in Figure 34 and Table 3, such that when mated with the module side, an air-gap is formed between the ferrule end-faces and the fibers do not physically contact. Additionally, an AR coating is applied to that facet to reduce insertion loss and back reflection from that interface. Furthermore, the fiber height of the air-gap ferrules differs from that of physical contact ferrules. These are defined in Table 4 and apply regardless of the application’s fiber count. This type of an air-gap interface may have advantages in the repeatability of its insertion loss and cleaning, and requires the same amount of mating force regardless of the fiber count.

Table 3 Permissible Facet Terminations

Config.	System/Host Side	Module Side	AR Coat	Mating
1			Host only	Air-gap
2			None	Physical contact

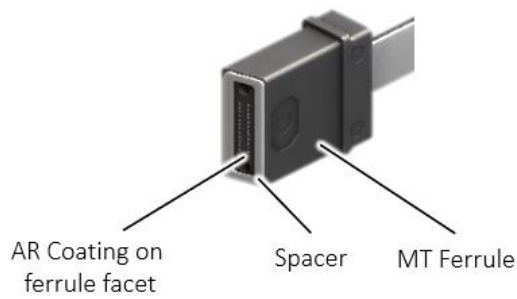
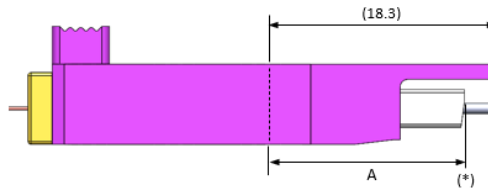


Figure 34 Air-gap MT ferrule

Table 4 Specifications for air-gap MT ferrule

Component	Parameter	Value	Applicable to
Anti-Reflection Coating	Reflectance	$\leq 0.5\%$ ($\lambda = 1260 - 1650 \text{ nm}$)	Host-side ferrule
Spacer Film	Material	Polyphenylene Sulfide (PPS)	Host-side ferrule
	Thickness	$9 \pm 2 \mu\text{m}$	
MT Ferrule	Fiber Height	1000-2500 nm	Host-side and Module-side ferrules

Requirements on Ferrule Travel and Mating Force



* Line indicates position of optical reference plane.

Ferrule Type	Physical Contact			Air-gap
	Fiber Ch. Count	12	24**	
Condition	THEN	THEN	THEN	THEN
IF				
F = 0 N	A = 16.16 ± 0.1 mm	A = 16.16 ± 0.1 mm	A = 16.16 ± 0.1 mm	A = 16.16 ± 0.1 mm
A ≤ 14.32mm	F ≥ 7.8 N * ¹	F ≥ 18.0 N * ²	F ≥ 18.0 N * ³	F ≥ 4 N
A ≥ 12.92 mm	F ≤ 11.8 N * ¹	F ≤ 22.0 N * ²	F ≤ 22.0 N * ³	F ≤ 6 N

- * F = mating force.
- ** Under further study. Requires thorough design of mechanical latching and springs.
- *¹ Equivalent to IEC 61754-7-1, TIA-604-5
- *² Equivalent to IEC 61754-7-2, TIA-604-5
- *³ Equivalent to TIA-604-5

Figure 35 Requirements on ferrule travel and contact force for optical mating

Figure 35 provides a table of required mating forces to properly mate the optical ferrules of the ELSFP blind mate connector.

3.4 Fiber wavelength and polarization assignments

Each application of the ELSFP will have a dedicated specification for critical laser parameters such as power, wavelength, RIN/back reflection tolerance, SMSR, etc. These specifications shall be maintained as requirements for the Optical Engine or CPO Module which the ELSFP is supporting. However, some fundamental characteristics of the fiber output such as the wavelength and polarization assignments for each fiber shall conform to the descriptions below. Additional fiber assignments, including those for pass through ELSFPs are to be kept in the Implementation Agreement for ELSFP CMIS.

3.4.1 MT-12, 4PMF and 8PMF Configurations for 1311nm and CWDM4 Applications

The position fiber naming and polarization output orientation conventions are defined in Figure 36 using either one or two MT-12 ferrules. Unused channels of the MT-12 must be populated with dummy fibers to prevent contamination or possible damage when falsely mating for example an 8 fiber and 4 fiber MT ferrule. If color-coding of fibers is used, fibers are suggested to be color coded following TIA-598-C standard coloring scheme [17] for grouped fibers to prevent 180 rotation misassignment in installation.

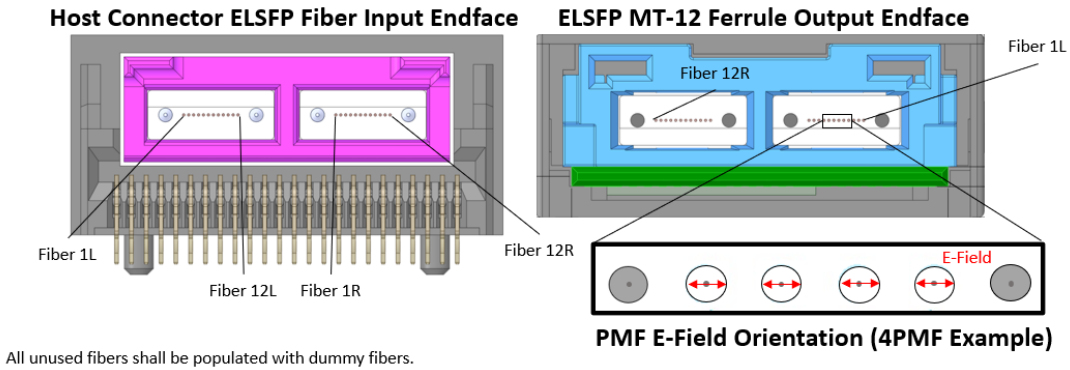


Figure 36 Fiber naming and polarization output definition

The output of the ELSFP shall have a polarization extinction ratio (PER, in dB) requirement specified by the application, but defined by the relative alignment of the output E-field with the horizontal line between the center of the two guide holes of the module’s MT “unpinned” ferrule. PER is defined in Figure 37 as a ratio of powers and can be measured at TP_{L2} with a test grade MT patch cord which contributes a negligible degradation to the PER or with an appropriately designed and calibrated free space setup for applications with a more stringent specification.

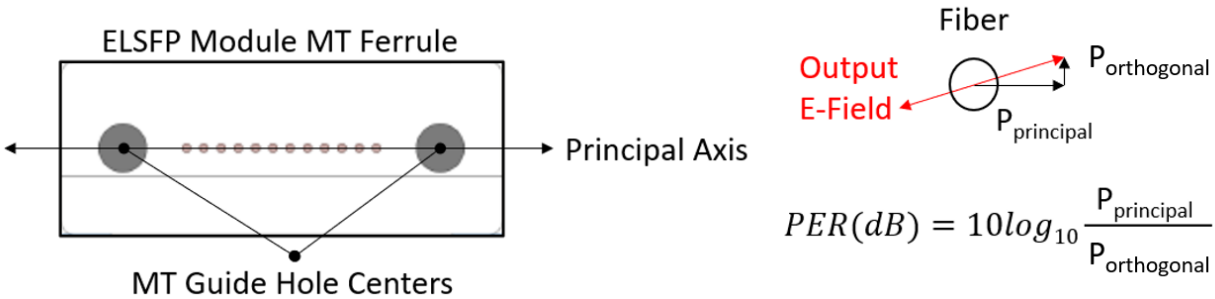


Figure 37 Polarization Extinction Ratio definition for MT ferrule output

A fiber naming convention is also defined in Figure 36. The ELSFP does not know what application and port it is used in. “Hard keys” specified in Figure 25 will not prevent mating of an 8PMF module into an 4PMF port, however the host is responsible for identifying the ELSFP’s capabilities as advertised via CMIS and comparing these with the system and assigning only the lasers fibers required by that port. Table 5 lists the assignment of wavelengths for 1311 (DR Type) and CWDM4 (FR Type) type modules relative to the fiber position. 4PMF and 8PMF per MT-12 ferrule configurations are specified.

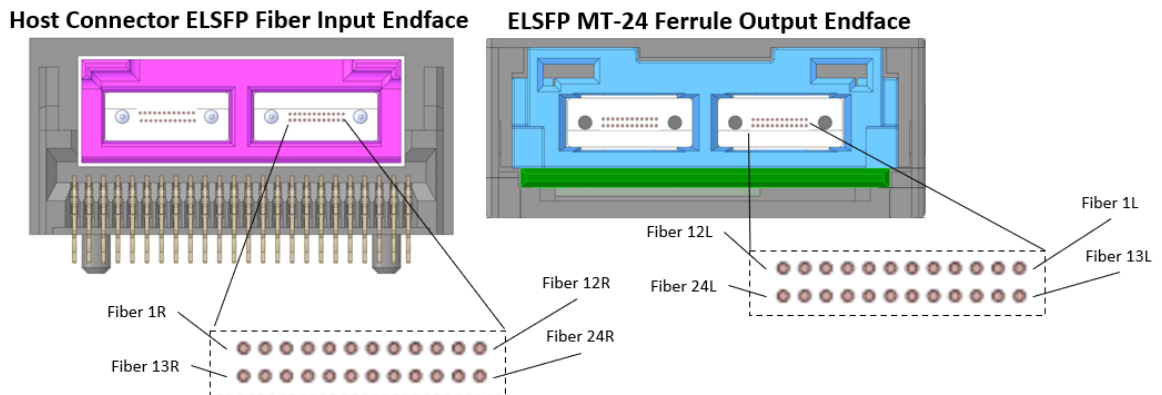
Table 5 DR type (1311) and FR type (CWDM4) wavelength assignment



Position	Symbol	CWDM4-4PMF	1311nm-4PMF	Symbol	CWDM4-8PMF	1311nm-8PMF
1L	NC	Dummy	Fiber	NC	Dummy	Fiber
2L	NC	Dummy	Fiber	NC	Dummy	Fiber
3L	NC	Dummy	Fiber	Laser3	1311	1311
4L	NC	Dummy	Fiber	Laser4	1331	1311
5L	Laser1	1271	1311	Laser1	1271	1311
6L	Laser2	1291	1311	Laser2	1291	1311
7L	Laser3	1311	1311	Laser7	1311	1311
8L	Laser4	1331	1311	Laser8	1331	1311
9L	NC	Dummy	Fiber	Laser5	1271	1311
10L	NC	Dummy	Fiber	Laser6	1291	1311
11L	NC	Dummy	Fiber	NC	Dummy	Fiber
12L	NC	Dummy	Fiber	NC	Dummy	Fiber

Position	Symbol	CWDM4-4PMF	1311nm-4PMF	Symbol	CWDM4-8PMF	1311nm-8PMF
1R	NC	Dummy	Fiber	NC	Dummy	Fiber
2R	NC	Dummy	Fiber	NC	Dummy	Fiber
3R	NC	Dummy	Fiber	Laser11	1311	1311
4R	NC	Dummy	Fiber	Laser12	1331	1311
5R	Laser5	1271	1311	Laser9	1271	1311
6R	Laser6	1291	1311	Laser10	1291	1311
7R	Laser7	1311	1311	Laser15	1311	1311
8R	Laser8	1331	1311	Laser16	1331	1311
9R	NC	Dummy	Fiber	Laser13	1271	1311
10R	NC	Dummy	Fiber	Laser14	1291	1311
11R	NC	Dummy	Fiber	NC	Dummy	Fiber
12R	NC	Dummy	Fiber	NC	Dummy	Fiber

By conforming to this convention ELSFP modules can be “soft keyed” by host management firmware which notifies the user of any mismatch between the port and module which isn’t captured by the hard keying system. This concept is extended to additional applications and fiber maps. For optical interfaces with 2 rows of fiber in 1 or 2 of the ELSFP ferrules, a fiber naming convention has been provided in Figure 38.



All unused fibers shall be populated with dummy fibers.

Figure 38 Fiber naming definition for 2 row/MT-24 ELSFP interface

For optical interfaces with 3 rows of fiber in 1 or 2 of the ELSFP ferrules, a fiber naming convention has been provided in Figure 39.

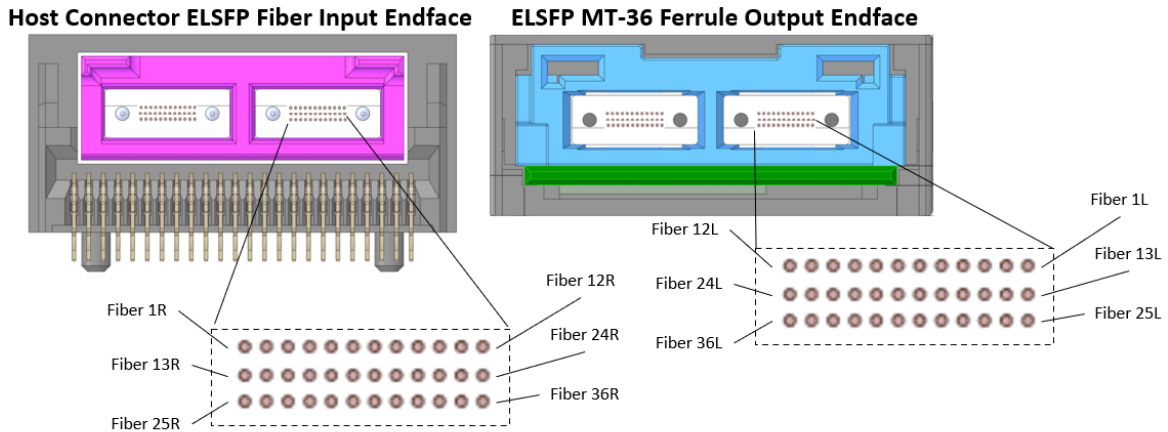


Figure 39 Fiber naming definition for 3 row/MT-36 ELSFP interface

For additional fiber assignment maps please reference the applications list maintained in the Implementation Agreement for ELSFP CMIS. If you have an application that is not captured in that list, please make a proposal to the OIF Management working group so as to reduce the total number of fiber assignment maps and diversity of ports and track them accordingly.

3.5 Optical Power Classes

Table 6 specifies the nominal fiber optical power for each of the optical power classes is measured at TP_{L2} described in §7.4.1. The power is specified per wavelength per core and follows the naming convention proposed in the ITU nomenclature for radio frequency band naming [18], so can be expanded to lower or high powers as required.

Table 6 Optical power classes

Optical Power Classes	Power/ λ /Core (+/- 1.5dB)
Low Power - LP	11dBm
Medium Power - MP	14dBm
High Power - HP	17dBm
Very High Power - VHP	20dBm
Ultra High Power - UHP	23dBm
Super High Power - SHP	26dBm

Laser drive circuits shall be implemented such that the bias achieves its set point so that the peak optical power for any fiber core does not exceed the steady state power for that bias set point by >1dB. This protects the ELSFP to OE fiber path and OE from potential optical damage and may also help to meet the ELSFPs inrush current rate specification in Table 9.

3.6 Test Point Definitions

3.6.1 Optical Test Point Definition

Optical test points shall be defined at the end of a patch cord connected on the host side of the blindmate connector on an appropriate test board which provides controls to the ELSFP.

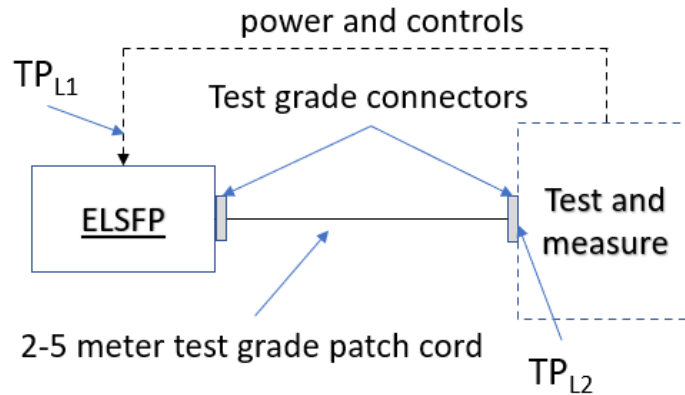


Figure 40 Optical test point definition

The ELSFP optical outputs are measured at TP_{L2} which is defined as the output of a short, 2-5 m, optical patch cord connected to an ELS optical output. The test grade patch cord and connector used shall be characterized sufficiently to remove or diminish its impact on the test results (i.e., the insertion loss, rotational and offset tolerances are known and exemplary).

4 Module Electrical and Controls Specifications

4.0 Module Electrical Interface Specification

A card edge host electrical connector with 24 pins shall match the corresponding pads in Figure 41.

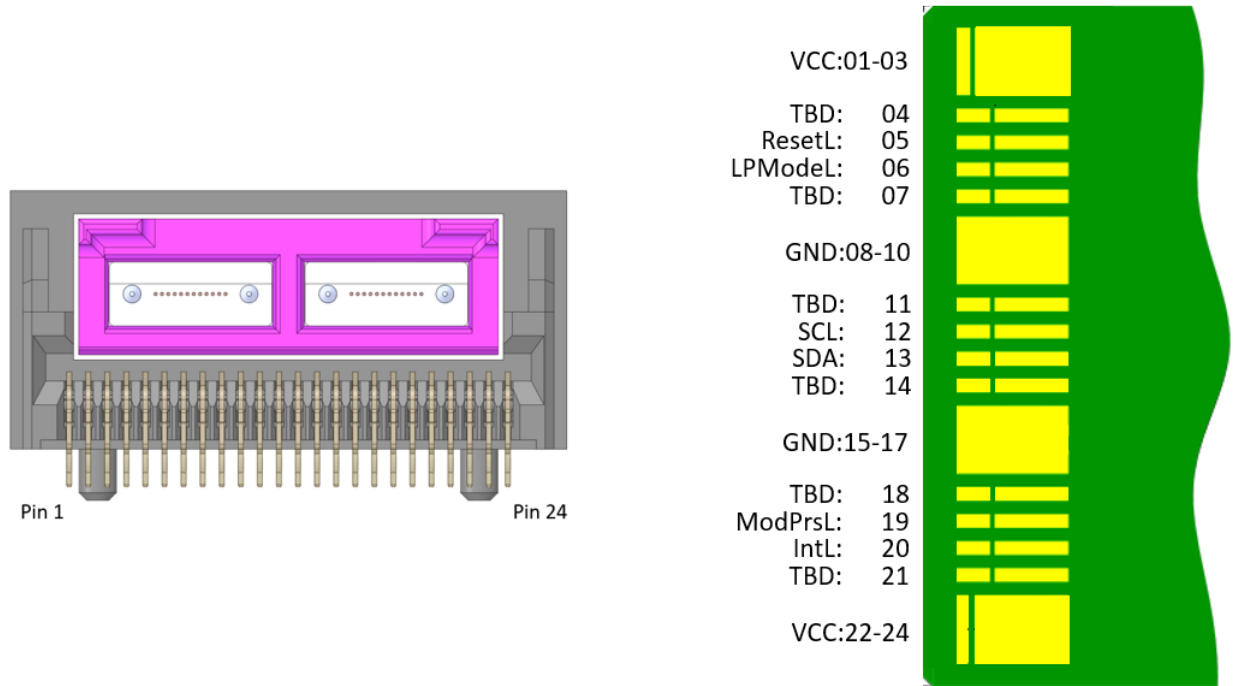


Figure 41 Host connector pin map and card edge

Note that to be determined (TBD) pins have been placed adjacent to the VCC and ground in the event that a future provision is required such as additional power and/or ground capacity. Additional notes for each pin are provided in Table 7. Similar to other CMIS compatible pluggable modules, the ModuleLowPwr state for the ELSFP module shall represent a minimum electrical power consumption state in order to power the module micro controller (MMC) and communicate with the Host. The ELSFP complies with the CMIS Module State Machine (MSM). When an ELSFP is initially plugged in the lasers' default state is OFF. First it is in the Resetting state. Upon completion of resetting, it enters the Reset state where it awaits a ResetS = FALSE signal and enters Management Initialization (MgmtInit). Once MgmtInit is complete the ELSFP enters the ModuleLowPwr or Low Power Mode state. Lasers shall ONLY be powered when the ELSFP module is in the ModuleReady state. To activate lasers the ELSFP must transition to the ModuleReady state and receive direction from the Host so as to maximize safety and prevent possible damage to the system or the optical engine. Only the Host Controller may request the Laser to be activated. Further details on management of the ELSFP are covered in the Implementation Agreement for ELSFP CMIS. Additional circuits, such as optional thermo-electric coolers (TECs) can be enabled prior to lasers. Table 7 also refers resistor values and noise filtering for the power supply detailed further in Figure 44 which are informative.

4.1 Electrical Pinout

The electrical interface pin definition for the ELSFP module is shown below. 24 electrical contacts are included in the host connector to mate to a card edge interface in the ELSFP module.

Table 7 ELSFP electrical pinout

Pin #	Function	Requirements	Notes
1	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering
2	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering
3	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering
4	TBD	TBD	(Reserved for future power)
5	ResetL	Pull up 10kΩ [1%]	Reset Module, LVTTTL
6	LPMoDeL	Only MMC on	Low power mode (low), LVTTTL
7	TBD	TBD	(Reserved for future ground)
8	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
9	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
10	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
11	TBD	TBD	TBD
12	SCL	TWI serial interface clock [19]	Host will have 4.7kΩ [1%] pull up, module will be >=10kΩ [1%] pull up, LVCMOS
13	SDA	TWI serial interface data [19]	Host will have 4.7kΩ [1%] pull up, module will be >=10kΩ [1%] pull up, LVCMOS
14	TBD	TBD	TBD
15	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
16	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
17	GND	1.5A, 3.3V	1.5A, 3.3V with noise filtering
18	TBD	TBD	(Reserved for future ground)
19	ModPrsL	Shorted to GND in module	Presence Pin (low), LVTTTL
20	IntL	Pull up 10kΩ [1%]	Interrupt LVTTTL
21	TBD	TBD	(Reserved for future power)
22	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering
23	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering
24	VCC	1.5A, 3.3V	1.5A, 3.3V with noise filtering

4.2 Mating Sequence and Presence Pin

The connector housing, ferrules and the electrical pads on the PCB are positioned such that during mating, the ferrules come into contact prior to electrical connection of the Presence Pin, thereby preventing powered (de)mating of the ELSFP module. The optical connector assemblies in the ELSFP module and the host are designed to engage in the following sequence leveraging the Presence Pin and optical connector spring.

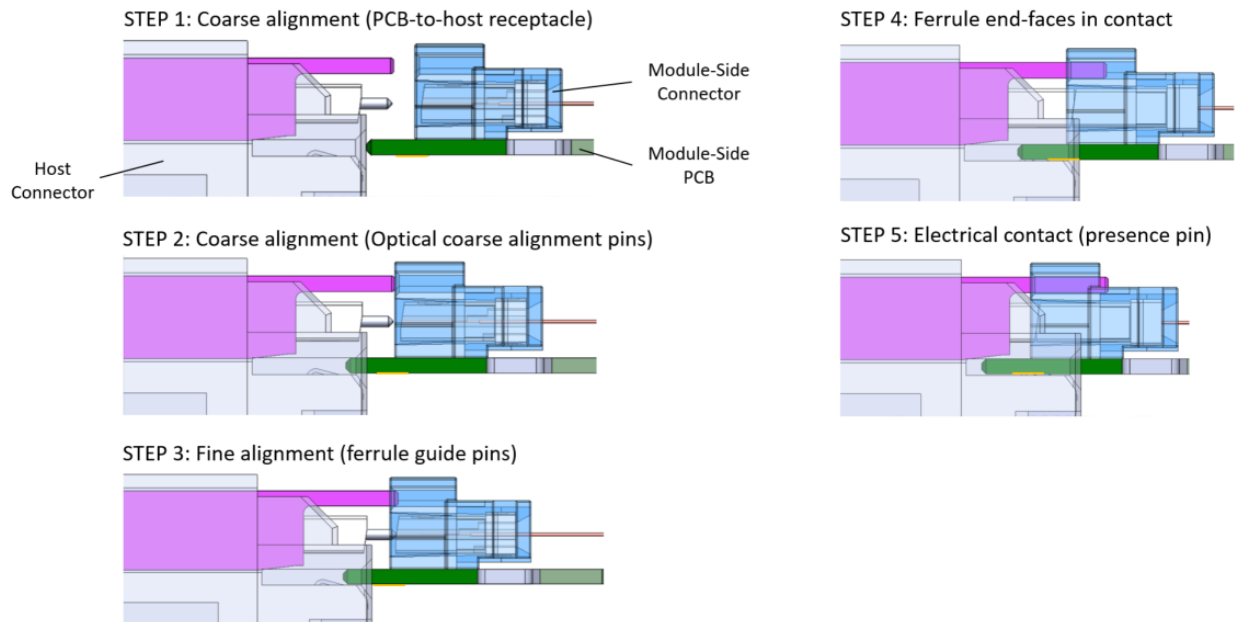


Figure 42 Mating sequence of eye-safe blindmate connector

- First, the module PCB engages with the host-side receptacle to provide the initial coarse alignment between module and host, though without making electrical contact.
- Second, coarse alignment between the module- and host-side optical connectors is performed, through the engagement of the coarse-alignment pins and guide-holes, on the host-side and module-side connector housings, respectively.
- Third, fine-alignment between the optical connectors is performed, through the engagement of fine-alignment guide-pins and holes, on the host-side and module-side ferrules, respectively.
- Fourth, the facets of the host-side and module-side ferrules come into contact. The spring-loaded host-side ferrules are pushed back into the host-side optical connector housing as the ELSFP module is inserted deeper into the cage.
- Lastly, electrical connection is made between the host-side electrical contacts and the pads on the module-side PCB.

This mating sequence is illustrated in Figure 42, and is designed to prevent powered (de)mating of the optical connectors. The module contains an automatic power-down feature that turns off optical emission when any presence pins are not engaged. The power down shall complete after disconnection of presence pin, but prior to the demating of the optical interface so as to prevent damaging that interface or causing a safety hazard.

4.3 Electrical Requirements

Power for the ELSFP shall be delivered by six pairs of 3.3V power and ground pins. The current capability of each of these pins is up to 1.5 A DC with a maximum operating rating voltage of 30 V DC . The total module power consumption of an ELSFP shall be reported via CMIS using the following electrical power classifications in Table 8. Current limits have also been supplied to ensure stable system power supply. Figure 43 provides an informative reference for the definitions of the various time and current limit specifications including those in Table 9.

Table 8 Electrical power classes and current Limits

	Power Consumption	Instantaneous peak current	Sustained peak current	Steady state current	CMIS Register
Electrical Power Class (#)	P_# (W) max	Icc_ip_# (mA) max	Icc_sp_# (mA) max	Icc_# (mA) max	Page 00h Byte 200
Low Power Mode (LP)	1.5	600	500	478	
Class 1 High Power Mode (1)	1.5	600	500	478	[000xxxxx]
Class 2 High Power Mode (2)	5	2000	1667	1595	[001xxxxx]
Class 3 High Power Mode (3)	10	4000	3333	3190	[010xxxxx]
Class 4 High Power Mode (4)	15	6000	5000	4785	[011xxxxx]
Class 5 High Power Mode (5)	20	8000	6666	6380	[100xxxxx]
Class 6 High Power Mode (6)	30	12000	9999	9569	[101xxxxx]
Class 7 High Power Mode (7)*	40	16000	13332	12759	[110xxxxx]
Class 8 High Power Mode (8)*	>40	P_8 * 400	P_8 * 333.3	P_8/Vcc_min	[111xxxxx]

All ELSFP modules shall report P_# max high power consumption per CMIS in MaxPower Byte 00h:201

*Note: A future revision may allocate additional power and ground pins to support power class 8.
ICC Host (A)

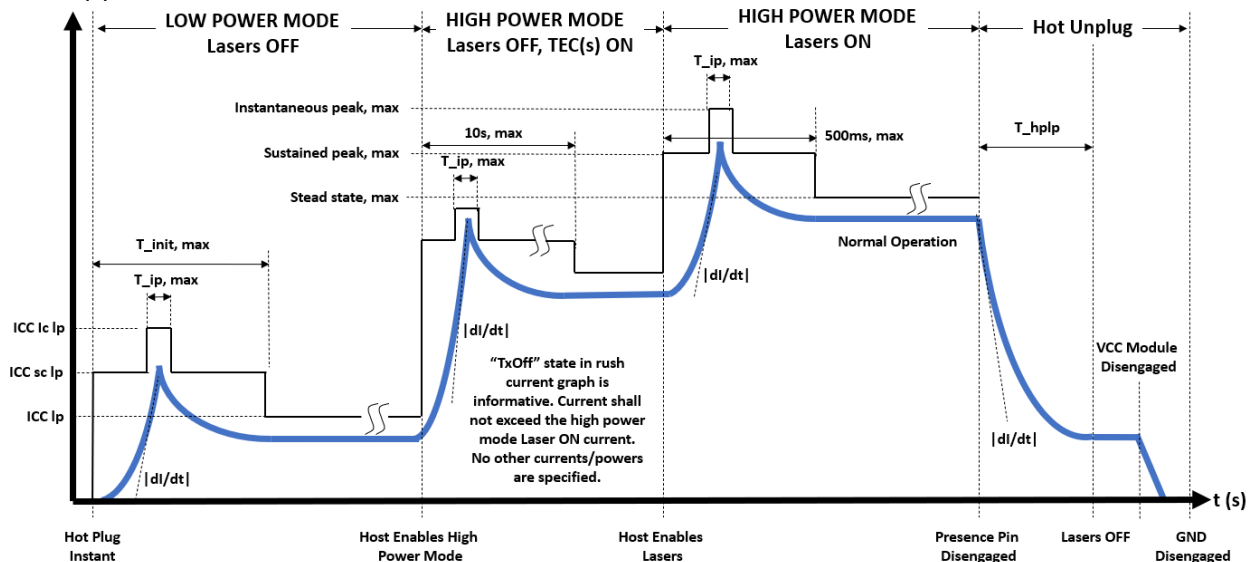


Figure 43 Instantaneous and sustained peak currents for Icc Host (see Table 8)

Table 9 Electrical power specifications

Parameter	Symbol	Minimum	Nominal	Maximum	Unit
ELSFP power supply voltage including ripple, droop, and noise below 100kHz	Vcc	3.135	3.3	3.465	V
Voltage drop across mated connector	Vcc_drop			66	mV
Total VCC Supply Current*	Icc			9	A
Host RMS noise output 10 Hz-10 MHz	eN_Host			25	mV
Module RMS noise output 10 Hz - 10 MHz	eN_Mod			15	mV
Module inrush - instantaneous peak duration	T_ip			50	μs
Module inrush - initialization time	T_init			500	ms
Inrush or discharge current rate**	di/dt			100	mA/μs
High power mode to Low power mode transition time from assertion of M_LPWn or M_RSTn or ForceLowPwr	T_hplp			200	μs
Notes:					
* Utilization of the maximum ELSFP electrical power rating requires thermal design and validation at the system level to ensure the maximum connector temperature is not exceeded. An informative design practice is to heatsink the host board power pin pads with multiple vias to a thick copper power plane for conductive cooling.					
** The specified Inrush or discharge current rate (di/dt) limit shall not be exceeded for all power transient events. This includes hot-plug, hot-unplug, power-up, power-down, initialization, low-power to high-power and high-power to low-power.					

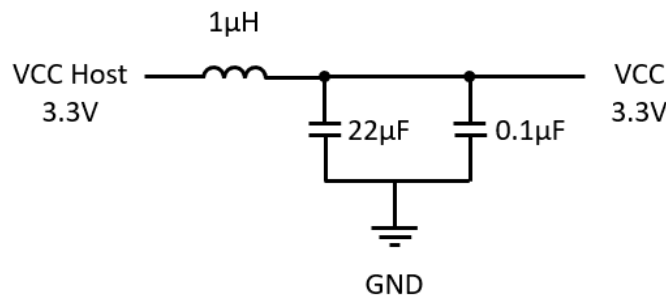


Figure 44 Example host board power filtering circuit

Figure 44 provides an example implementation for a 3.3V power filter on the host board. The filter network may not be required if there is a dedicated DC-DC convertor per ELSFP. One may use multiple instances of the same RLC network with the same component values with reduced current handling. Additionally, tantalum capacitors are the preferred recommendation, in order to avoid strong natural resonance at corner frequencies for some ceramic alternatives. This is only an informative recommendation to use as a reference design.

4.4 ESD – Electro-Static Discharge

Where ESD performance is not otherwise specified, e.g., in the Ethernet specification, ELSFP modules shall meet ESD requirements given in EN61000-4-2, criterion B test specification when installed in a properly grounded cage and chassis. The units are subjected to 15 kV air discharges during operation and 8 kV direct contact discharges to the case. All the ELSFP modules and host pads including high speed signal pads shall withstand 1000 V electrostatic discharge based on Human Body Model per JEDEC JS-001 [12] [13] and IEC EN61000-4-2 [14].

5 Management Interface

The ELSFP module shall comply to the Common Management Interface Specification (CMIS 5.3 or later). The ELSFP shall have a two wire interface (TWI). It shall consist of a minimum of 5 pins: 2 serial pins designated for clock (SCL) and for data (SDA). CMIS 5.3 or later also requires ResetL, IntL, and LPModel signals, for which pins have been assigned.

5.0 Common Management Interface Specification

The common management interface specification (CMIS 5.3 or later) used with ELSFP is also used for the [OIF-Co-Packaging-3.2T-Module-01.0 – Implementation Agreement for a 3.2Tb/s Co-Packaged \(CPO\) Module](#). A specific project describing the interface between the Host, CPO and ELSFP is managed within the OIF Management Working Group, so the reader is directed to [updates to CMIS and Implementation Agreement for ELSFP CMIS](#) and any white papers coming out of this group specific to ELSFP and CPO management.

6 ELSFP Designations and Labeling Conventions

6.0 ELSFP Module Capability Identification Designation

In order to better ensure port to module compatibility, ELSFP Modules shall be designated by their basic optical characteristics as follows:

ELSFP Designation: **a*MF-*bb*#-cc-*kkkkkkk*

(*) = Number of fibers

(a) = Type of fiber (i.e., SMF, PMF)

(bb) = Power per Wavelength / Core (*HP, VHP, UHP* – Optical Power classes in Table 6)

(#) = Wavelengths per core (i.e., 1,2,4,8)

(cc) = Application dictates CPO interface supported wavelengths (i.e., CWDM4, 1311)

(*kkkkkkk*) = Physical key designation in binary

Example ELSFP Designations:

8PMF-VHP1-CWDM4-1101110

This module has (2) single row MT-12 ferrules, each with 4 active polarization maintaining fibers (8 in total), that deliver 20+/-1.5dBm each and meet the wavelength requirements of the CWDM4 standards (i.e., 1271, 1291, 1311, 1331 nominal wavelength)

4PMF-UHP1-1311-1101110

This module has (1) single row MT-12 ferrule, each with 4 active polarization maintaining fibers, that deliver 23+/-1.5dBm each and meet the wavelength requirements of the 1311 nm standards such as 400G-BASE-DR4 (i.e., 1311 nominal wavelength)

4PMF-VLP8-CWDM18nmFixed-1111110

This module has (1) single row MT-12 ferrule, with 4 active polarization maintaining fibers, that deliver 8+/-1.5dBm in each of 8 wavelengths meeting the wavelength requirements of the CW-WDM MSA's 18nm span (i.e., 1293.32, 1295.56, 1297.80, 1300.05, 1302.31, 1304.58, 1306.85, 1309.14: fixed nominal 400GHz channel spacing, corresponding to the CW-WDM's Type 1 maximum output power class)

6.1 Labeling Convention

It is recommended that ELSFP modules be clearly labelled, and such a label may include:

Manufacturing and part number in compliance with the above ELSFP designation

Regulatory compliance labelling

A manufacturing traceability code

Additional labels may be required to be placed on the top of the module for the module to follow safety regulations, for example high touch temperature labelling, etc.

Labelling shall not interfere with requisite mechanical, thermal or EMI features.

7 Module Environmental and Thermal Requirements

ELSFP modules are designed to allow for up to 16 modules in single cages across a 19" rack; Additionally, by use of ganged and/or belly-to-belly higher ELSFP modules counts are possible with the appropriate thermal design for cooling/airflow.

The equipment supplier is responsible for controlling the module case temperature to the specified range. The module supplier is responsible for defining a point on the module case where the temperature is measured. This should be a point connected to an internal component with the least thermal margin, e.g., a laser diode(s) or the “hot” side of the TEC opposite the laser(s). It is not necessarily the hottest point of the module surface. The module supplier can establish a monitor point for case temperature at a location of interest for touch temperature, i.e., outside the faceplate. An internal temperature sensor or sensors could provide a correlation to this point. The module should also report thermal margin or temperatures for specific critical internal components, including the laser(s), module micro controller, power supplies, and any TECs. These components can then have more well monitored maximum operating temperatures to provide future design flexibility and wider component selection. ELSFP module suppliers should provide system designers with sufficient module modelling information to establish component thermal margin in their systems while maintaining case temperature within limits. This information is outlined in IA OIF-Thermal-01.0 Section 6.

7.0 Thermal Requirements

The module case temperature may be within one or more of the case temperatures ranges defined in Table 10. The temperature ranges are applicable between 60 m below sea level and 1800m above sea level, utilizing the host systems designed airflow. For further information see Telcordia GR-63-CORE, Issue 5, December 2017, NEBSTM Requirements: Physical Protection.

Table 10 Temperature Range Class of Operation

Class	Module Case Temperature
Standard	0°C through 70°C
Extended	-5°C through 85°C
Industrial	-40°C through 85°C

7.1 External Case and Handle Touch Temperature

For all power classes, all module case and handle surfaces outside of the cage must comply with applicable touch temperature requirements. If the module case temperature will exceed applicable short-term touch temperature limits, a means must be provided to prevent contact with the case during unlatching and removal. Handles are typically low thermal conductivity elastomer and allow for a higher touch temperature, see IEC/UL 60950-1 [4] and Telcordia GR-63-CORE [19].

8 Form Factor Performance Requirements

EIA-364-1000 shall be used to define the test sequences and procedures for evaluating the ELSFP connector systems described in this document. Where multiple test options are available, the manufacturer shall select the appropriate option where not previously specified. The selected procedure should be noted when reporting data. If there are conflicting requirements or test procedures between EIA-364 procedures and those contained within this document, this document shall be considered the prevailing authority. Unless otherwise specified, procedures for sample size, data, and collection to be followed as specified in EIA-364-1000. See EIA-364-1000 Annex B for objectives of tests and test groups. This document represents the minimum requirements for the defined product. Additional test conditions and evaluations may be conducted within the defined EIA-364-1000 sequences. More extreme test conditions and failure criteria may be imposed and still meet the requirements of this document.

8.0 Test Requirements

Table 11 summarizes the performance criteria that are to be satisfied by the connector described in this document. Most performance criteria are validated by EIA-364-1000 testing, but this test suite leaves some test details to be determined. To ensure that testing is repeatable, these details are identified in Table 12. Finally, testing procedures used to validate any performance criteria not included in EIA-364-1000 are provided in Table 13.

Table 11 Form Factor Performance Requirements

Parameters	Description/ Details	Requirements
Mechanical/ Physical Tests		
Plating Type	Plating type on connector contacts	Precious
Surface Treatment	Surface treatment on connector contacts; if surface treatment is applied, Test Group 6 is required	Manufacturer to specify
Wipe length	Designed distance a contact traverses over a mating contact surface during mating and resting at a final position. If less than 0.127 mm, test group 6 is required	Manufacturer to specify
Rated Durability Cycles	The expected number of durability cycles a component is expected to encounter over the course of its life	Connector/ cage: 100 cycles Module: 50 cycles
Mating Force*	Amount of force needed to mate a module with a connector when latches are deactivated	100 N MAX
Unmating Force*	Amount of force needed to separate a module from a connector when latches are deactivated	45 N MAX
Latch Retention*	Amount of force the latching mechanism can withstand without unmating	90 N MIN
Cage Latch Strength*	Amount of force needed to mate a module with a connector when latches are deactivated	125 N MAX
Cage Retention to Host Board*	Amount of force a cage can withstand without separating from the host board when a vertical load is uniformly distributed across the cage	180 N MIN
Environmental Requirements		
Field Life	The expected service life for a component	10 years
Field Temperature**	The expected service temperature for a component	65°C

Electrical Requirements		
Current	Maximum current to which a contact is exposed in use	0.5 A per signal contact MAX 1.5 A per power contact MAX
Operating Rating Voltage	Maximum voltage to which a contact is exposed in use	30 V DC per contact MAX
Note: * These performance criteria are not validated by EIA-364-1000 testing, see Table 13 for test procedures and pass/fail criteria. ** Field temperature is the ambient air temperature around the component.		

Table 12 describes the details necessary to perform the tests described in the EIA-364-1000 test sequences. Testing shall be done in accordance with EIA-364-1000 and the test procedures it identifies in such a way that the parameters/ requirements defined in Table 11 are met. Any information in this table supersedes EIA-364-3 1000.

Table 12 EIA-364-1000 Test Details

Performance Parameters	Description/ Details	Requirements
Mechanical/ Physical Tests		
Durability (preconditioning)	EIA-364-09 To be tested with connector, cage, and module. Latches may be locked out to aid in automated cycling.	No evidence of physical damage
Durability*	EIA-364-09 To be tested with connector, cage, and module. Latches may be locked out to aid in automated cycling.	No visual damage to mating interface or latching mechanism Environmental Tests
Cyclic Temperature and Humidity	EIA-364-31 Method IV omitting step 7a Test Duration B	No intermediate test criteria
Vibration	EIA-364-28 Test Condition V Test Condition Letter C Test set-up: Connectors may be restrained by a plate that replicates the system panel opening as defined in this specification. External cables may be constrained to a non-vibrating fixture a minimum of 8 inches from the module. For cabled connector solutions: Wires may be attached to PCB or fixed to a non-vibrating fixture.	No evidence of physical damage -AND- No discontinuities longer than 1 μs allowed
Mixed Flowing Gas	EIA-364-65 Class II See Table 4.1 in EIA-364-1000 for exposure times Test option Per EIA-364-1000 option 3	No intermediate test criteria Electrical Tests
Electrical Tests		
Low Level Contact Resistance**	EIA-364-23 20 mV DC Max, 100 mA Max To include wire termination or connector-to-board termination	20 mΩ Max change from baseline
Dielectric Withstanding Voltage	EIA-364-20 Method B 300 VDC minimum for 1 minute Applied voltage may be product / application specific	No defect or breakdown between adjacent contacts -AND- 1 mA Max Leakage Current
Notes: * If the durability requirement on the connector is greater than that of the module, modules may be replaced after their specified durability rating. ** The first low level contact resistance reading in each test sequence is used to determine a baseline measurement. Subsequent measurements in each sequence are measured against this baseline.		

Table 13 describes the testing procedures necessary to validate performance criteria not validated by EIA-364-1000 testing. The tests are to be performed in such a way that the parameters/ requirements defined in Table 11 are met.

Table 13 Additional Test Procedures

Tests	Test Descriptions and Details	Pass/ Fail Criteria
Mechanical/ Physical Tests		
Mating Force*	EIA-364-13 To be tested with cage, connector, and module. Latching mechanism deactivated (locked out).	Refer to Table 11 -AND- No physical damage to any components
Unmating Force*		
Latch Retention*	EIA-364-13 To be tested with cage, connector, and module. Latching mechanism engaged (not locked out).	
Latch Strength	An axial load applied using a static load or ramped loading to the specified load. To be tested with cage, connector, and module or module representative tool without heat sinks Latching mechanism engaged (not locked out).	
Cage Retention to Host Board	Tested with module, module analog, or fixtures mated to cage. Pull cage in a direction perpendicular to the board at a rate of 25.4mm/min to the specified force.	No physical damage to any components -AND- Cage shall not separate from board
Electrical Tests		
Current	EIA-364-70 Method 3, 30-degree temperature rise Contacts energized: All signal and power contacts energized simultaneously	Refer to Table 11 for current magnitude
Note: * Values listed in Table 11 apply with or without the presence of a riding heat sink.		

9 Summary

This External Laser Small Form-factor Pluggable (ELSFP) Implementation Agreement (IA) details the minimum specifications for interoperability in a multi-vendor ecosystem and provides specific examples in some cases for informative purposes. As each application will have specific optical requirements (i.e., power, noise, wavelength, these have intentionally not been included in this IA). Some of the many applications for ELSFP are covered in the [OIF-Co-Packaging-FD-01.0 – Co-Packaging Framework Document](#). Some basic goals for this form factor include:

- 16 modules per row of an 18” standard rack
- 1 or 2 MT-compatible physical contact or air-gap ferrules to enable servicing multiple OEs
- 1x1, 1x4 and belly to belly configurations
- Compatible with both 4 and 8 fiber proposals for Implementation Agreement for a 3.2Tb/s Co-Packaged (CPO) Module
- Additional volume above module PCB for diverse laser package options
- Flexible and enhanced riding heat sink thermal design vs. OSFP or QSFP-DD: increased size and airflow are possible for diverse system cooling requirements

10 References

Foundational references for laser safety

1. IEC 60825-1:2014 “Safety of laser products -Part 1: Equipment classification and requirements”
2. IEC 60825-2:2021 “Safety of laser products -Part 2: Safety of optical fiber communication systems (OFCSs)”
3. IEC 60825-17:2015 “Safety of laser products -Part 17: Safety aspects for use of passive optical components and optical cables in high power optical fiber communication systems”
4. IEC 60950-1:2005, with amendments AMD1:2009, AMD2:2013 “Information technology equipment – Safety –Part 1: General requirements”

Published standards and other contributions, that apply the foundational references

5. https://www.ieee802.org/3/10GEPON_study/email/msg00156.html (2006) -Comments by Peter Anslow
6. oif2021.359.00 “Laser Safety for Multiple Channel External Laser Sources”, Bing Shao, Jock Bovington, Matt Traverso, Mark Nowell -Cisco
7. IEEE 802.3bs section 124.9.2 Laser safety (for 400GBASE-DR4)
8. IEEE 802.3cu section 151.9.2 Laser safety (for 400GBASE-FR4)
9. ITU-T G.664 10/2012 “SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS: Transmission media and optical systems characteristics –Characteristics of optical components and subsystems: Optical safety procedures and requirements for optical transport systems”
10. ITU-T G.664 12/2014 Amendment 1 “SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS: Transmission media and optical systems characteristics –Characteristics of optical components and subsystems: Optical safety procedures and requirements for optical transport systems”
11. “Co-packaged Optics External Laser Source Guidance Document v1.0”, CPO JDF
12. Human Body Model per ANSI/ESDA/JEDEC JS-001
13. EN6100-4-2 (IEC immunity standard on ESD), criterion B test specification
14. JEDEC JESD8C.01 Interface Standard for Nominal 3.0/3.3 V Supply Digital Integrated Circuit (LVCMOS)
15. TIA-604-5 “FOCIS 5 Fiber Optic Connector Intermateability Standard- Type MPO”
16. IEC 61754-7-1 “Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 7-1: Type MPO connector family - One fibre row”
17. TIA-598-C Optical Fiber Cable Color Coding
https://web.archive.org/web/20120710203543/http://www.nds.com.vn/images/download/_Cabling%20Standard%20-%20TIA%20598%20A%20-%20FO%20Cable%20Color%20Coding.pdf

18. ITU Radiocommunication Article 2 Nomenclature, Section I – Frequency and Wavelength Bands
<https://web.archive.org/web/20111001005059/http://life.itu.int/radioclub/rr/art02.htm>
19. EIA-364-70D, Temperature Rise Versus Current Test Procedure for Electrical Connectors and Sockets, Revision D, May 2021.
20. Telcordia GR63 NEBSTM Requirements: Physical Protection, Section 4.1.7, December 2017
21. ISO 21920-2, Geometrical product specifications (GPS) — Surface texture: Profile — Part 2: Terms, definitions and surface texture parameters, 2021

11 Appendix A: Interpretation of eye safety requirements for high power ribbon fibers

ELSFP implementations shall meet IEC 60825-2 Hazard Level 1 when used as specified. Conformance to additional laser safety standards may be required for operation within specific geographic regions.

11.0 ELSFP Interface with System Interlock

(2) ELSFP mid-board connector

(1) ELSFP blind mate connector

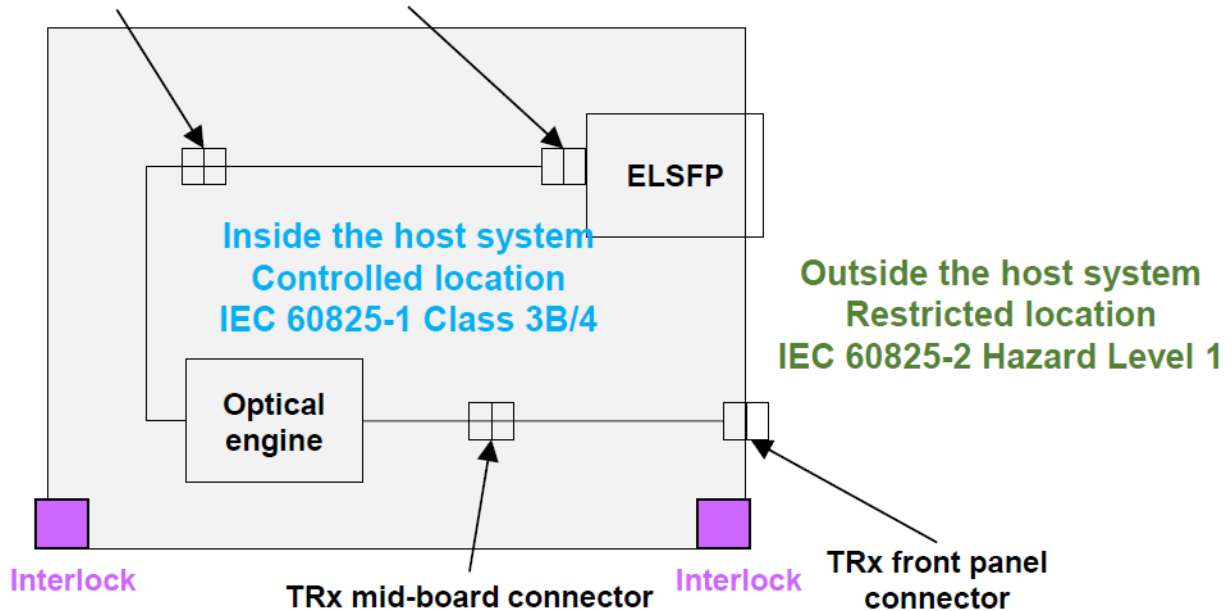


Figure 45 System Interlock Example with ELSFP

11.1 Automatic Power Reduction

Systems without an interlock must execute Automatic Power Reduction (APR) within 250ms and fibers conforming to fiber assignment Figure 36 and Table 5 must not exceed 24.5 dBm/fiber in order to maintain Hazard level 1.

12 Appendix B: Recommended ELSFP laser power turn-on procedure

The ELSFP generates a high-level of optical power (>~15dBm/fiber) to support multiple optical modulators of an optical engine. It has been experimentally shown when the ELSFP is operated in high-power output mode that any contamination present in the optical connector light path (particle, dust, condensation, or any foreign body) will result in permanent damage through “burning” of the material or of the connector ferule. “Burning” on the ELSFP optical connectors will result in catastrophic damages to the system that may only be remediated through factory return. The following section will provide recommendations for system operation and implementation of host systems control software in-order to minimize the chances of damages through optical burning.

12.0 Optical inspection and cleaning of host and ELSFP optical connectors

When inserting an ELSFP in the system faceplate, both mating MT surfaces of the ELSFP shall be thoroughly inspected following the IEC 61300-3-35 standard for facet inspection and cleaned using connector manufacturer recommended cleaning procedure. Properly cleaning the MT ferules will ensure a minimum amount of contaminant is present after insertion. Caution should also be taken when using, so called “wet” cleaning procedures. Residual cleaning solution left on optical facets is also a form of contamination which can result permanent facet damage. Please consult appropriate inspection and cleaning procedures provided by system and connector vendors.

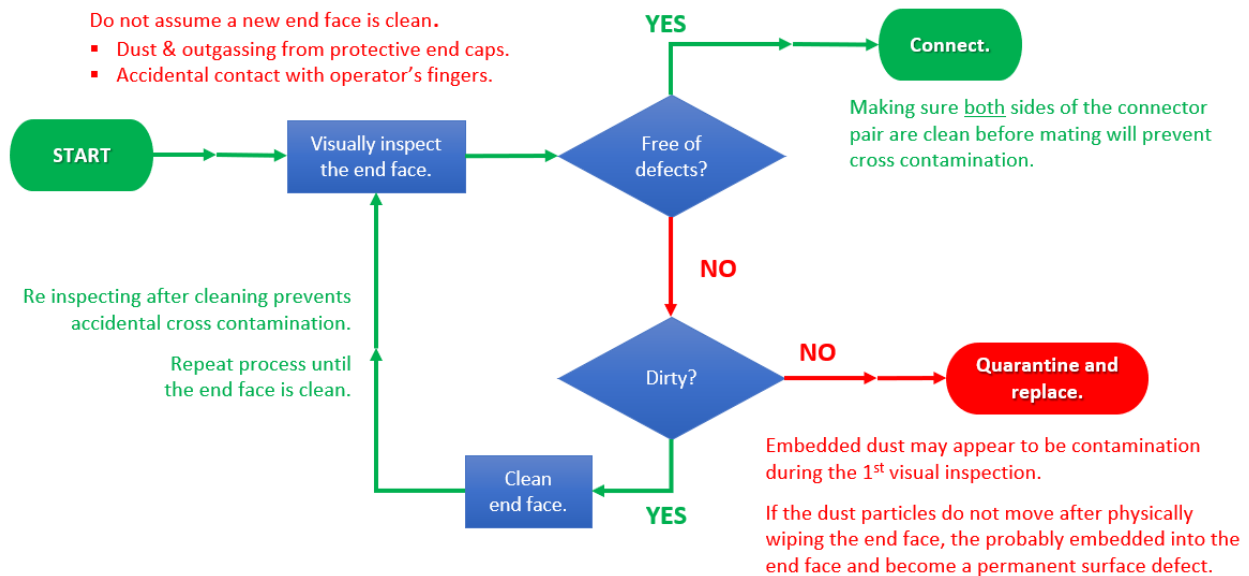


Figure 46 Fiber optic inspection and cleaning procedure

12.1 Optical loss measurement

Inspection and cleaning alone will not guarantee the absence of contaminants within the connector light path. Host software implementors should utilize a link loss verification procedure before requesting full operational output power from an ELSFP.

Individual link loss can be assessed by the host system software by the following procedure in Figure 47.

- 1) The host controller sets the ELSFP lasers P_0 to a low safe initial value first ($< \sim 15\text{dBm}$)
- 2) The host controller measures the received optical power from the corresponding CW light input port on the optical engine P_1 . The ELSFP to OE insertion loss is the difference between P_0 and P_1 .
- 3) The insertion loss is compared to the expected value of loss for this specific link in the system.
Note: it is also advisable to compare the loss of multiple fiber paths from the ELSFP in relative terms to identify potential contamination of one of more optical connections.
- 4) The ELSFP is set to high power only when the optical path loss is within specifications.

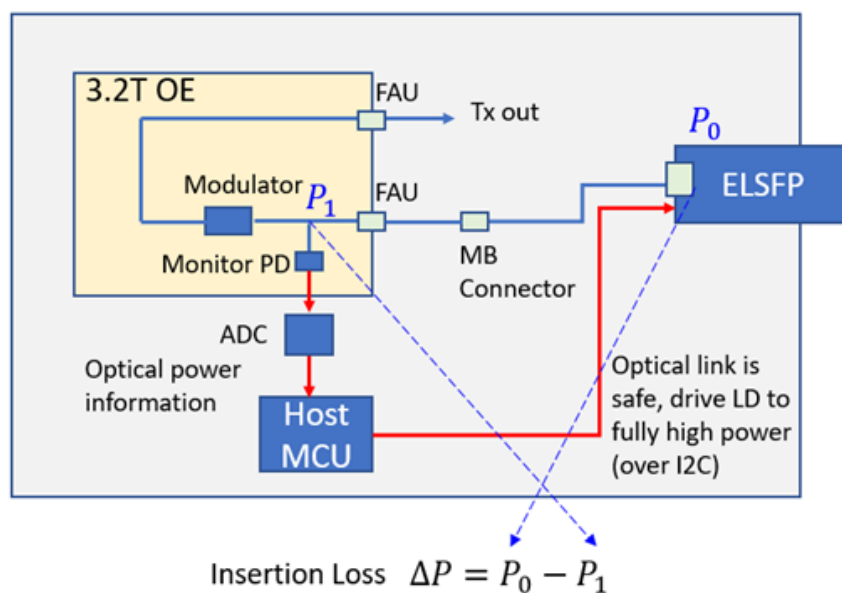


Figure 47 ELSFP to OE optical loss measurement

The full procedure to minimize the catastrophic “burning” damage on the connector of the ELSFP is illustrated in Figure 48.

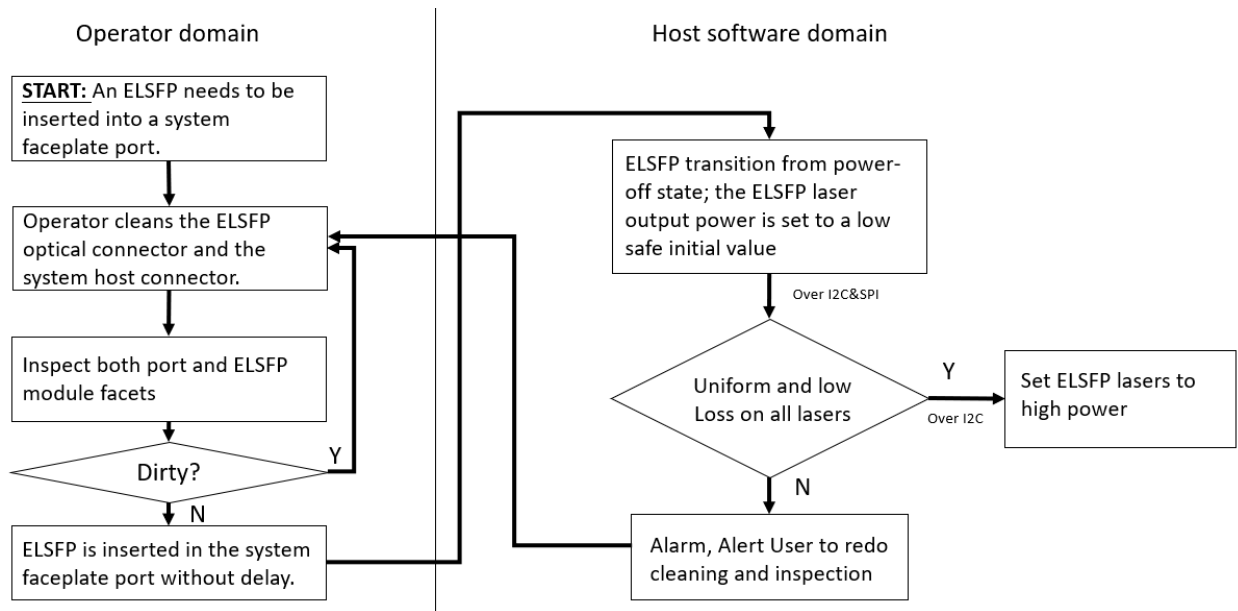


Figure 48 Recommended ELSFP power turn-on procedure

13 Appendix C: Glossary

A – Ampere

AR – Anti-Reflection

ASIC – Application Specific Integrated Circuit

CEA – [Consumer Electronics Association](#)

Ch. - Channel

CMIS – Common Management Interface Specification

CPO – Co-Packaged Optical

CW – Continuous Wave

CWDM – Course Wavelength Division Multiplexing

dB – Decibel

DC – Direct Current

di/dt – change in current over time

DR – 500m single mode link specification at 1311 nm channel(s)

E-Field – Electric Field

ECIA - [Electronic Components Industry Association \(ECIA\)](#)

EIA – [Electronic Industry Alliance](#)

ELSFP – External Laser Small Form-Factor Pluggable

EMI – Electro-Magnetic Interference

ESD – Electro-Static Discharge

FR - 2000m single mode link specification with CWDM 1271, 1291, 1311 and 1331 nm channels

GND – Ground

HP – High Power

IEC – International Electrotechnical Commission

IEEE – International Electrical and Electronic Engineers

ITU – International Telecommunications Union

JEDEC - [Joint Electron Device Engineering Council](#)

I – Current

I_{cc} – Common Collector Current

LP – Low Power

LVC MOS – Low Voltage Complementary Metal-Oxide-Semiconductor

LVTTL – Low Voltage Transistor-Transistor Logic

MgmtInit – Management Initialization

ModPrsL – Module Presence

MP – Medium Power

MT – Mechanical Transfer, refers to the ferrule of an optical interface with parallel fibers common in the industry and detailed in the referenced specifications from IEC and TIA.

OE – Optical Engine, refers to the CPO module

PCB – Printed Circuit Board

PER – Polarization Extinction Ratio

PMF – Polarization Maintaining Fiber

PPS - Polyphenylene Sulfide

RIN – Relative Intensity Noise

SCL- Serial Clock

SDA – Serial Data

SHP – Super High Power

SMF – Single Mode Fiber

SMSR – Side-Mode Suppression Ratio

TBD – To be determined

TIA - [Telecommunications Industry Association](http://www.itu.int/ITU-T/terrestrial/optical/)

TP – Test Point

UHP – Ultra High Power

V – Voltage

V_{CC} – Common Collector Voltage

VHP – Very High Power

14 Appendix D: Open Issues / current work items

This document is officially in maintenance. If you have proposals for revision, please upload your proposal to ARO and reach out to the Chair and Editor for time on a future agenda to discuss them with the working group.

15 Appendix E: List of companies belonging to OIF when document is approved

Accelight Technologies, Inc.	HGGenuine Optics Tech Company	Quantifi Photonics USA Inc.
Accton Technology Corporation	Hirose Electric Co. Ltd.	Quintessent Inc.
Advanced Fiber Resources (AFR)	Hisense Broadband Multimedia	Ranovus
Advanced Micro Devices, Inc.	Huawei Technologies Co., Ltd.	Retym
AIO Core Co., Ltd	Infinera Corporation	Rosenberger
Alibaba	InfiniLink	Hochfrequenztechnik GmbH & Co. KG
Alphawave Semi	Integrated Device Technology	Ruijie Networks Co., Ltd.
Amazon	Integrated Device Technology	Samsung Electronics Co. Ltd.
Amphenol Corp.	Intel	Samtec Inc.
Applied Optoelectronics, Inc.	Juniper Networks	SCINTIL Photonics
Arista Networks	Kandou Bus	Semtech Canada Corporation
Astera Labs	KDDI Research, Inc.	Senko Advanced Components
ATOP Corporation	Keysight Technologies, Inc.	SeriaLink Systems Ltd.
BitifEye Digital Test Solutions GmbH	KYOCERA Corporation	Sicoya GmbH
BizLink Technology, Inc.	Lessengers Inc.	SiFotonics Technologies Inc.
Broadcom Inc.	Lightmatter	Silith Technology
Cadence Design Systems	Linktel Technologies Co., Ltd.	Socionext Inc.
Casela Technologies USA	Lumentum	Source Photonics, Inc.
Celestica	Lumiphase AG	Spirent Communications
China Telecom	LUXIC Technology Co	Sumitomo Electric Industries, Ltd.
CICT	Luxshare Technologies International, Inc.	Sumitomo Osaka Cement
Ciena Corporation	MACOM Technology Solutions	Synopsys, Inc.
Cisco Systems	Marvell Semiconductor, Inc.	TE Connectivity
Coherent	MaxLinear Inc.	Tektronix
ColorChip LTD	MediaTek	Telefonica S.A.
Cornelis	Meta Platforms	TELUS Communications, Inc.
Corning	Microchip Technology Incorporated	TeraHop US
Dai Nippon Printing Co., Ltd.	Microsoft Corporation	Teramount
Dell, Inc.	Mitsubishi Electric Corporation	US Conec
Dexerials Corporation	Molex	Viavi Solutions Deutschland GmbH
DustPhotonics	Multilane Inc.	Wilder Technologies, LLC
EFFECT Photonics B.V.	NEC Corporation	Wistron Corporation
Eoptolink Technology	Nokia	Xphor Ltd.
Epson Electronics America, Inc.	NTT Corporation	Yamaichi Electronics Ltd.
Ericsson	Nubis Communications, Inc.	ZTE Corporation
EXFO	NVIDIA	
Foxconn Interconnect Technology Ltd	O-Net Technologies (Shenzhen) Group Co., Limited	
Fujikura	Omatrix Ltd Co	
Fujitsu	Omniva LLC	
Furukawa Electric Co., Ltd.	Optomind Inc.	
Global Foundries	Orange	
Google	PETRA	
H3C Technologies Co., Ltd.	Point2 Technology	
Hakusan Inc	Precision Optical Transceivers, Inc.	
Hakusan Inc		
Hewlett Packard Enterprise		